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and more equitable in comparison to the views of some of the groups in the decade 1930–1940. The science of building malaria out of surface water impoundments has gained fairly wide-spread recognition and application. In the future this should reflect itself by reducing the "man-made" malaria potential.

The residual qualities of the new insecticides, such as DDT, permit at last a practicable and efficient approach to the previously unsolved problem of malaria control in unscreened, isolated dwellings. This advance is of paramount importance since it is largely in rural areas that indigenous malaria simmers today. In research, significant progress continues in the fields of chemotherapy and parasitology. There are promising leads toward the goal of effecting truly prophylactic and curative drugs of low toxicity. Under the war-spawned impetus, thousands of compounds were synthesized and tested. Existing voids in our knowledge in the life history of malaria parasites of birds have been filled by Huff and his co-workers; it is not too much to expect that similar achievements soon will be reported for man.

For the past three years, the southern state health departments, with federal assistance, have brought DDT residual spray techniques closer to perfection and have beamed this malaria control measure of proven efficiency against areas of traditional endemicity. Although aimed originally at offsetting the impact of the returning malaria carrier, the extended program now includes several hundred counties in 13 states where the basic principles of the 1943 eradication plan are being applied with singular success. Some 2,000,000 house-spray applications are involved at an annual cost in excess of $6,000,000.

It is most unfortunate that a truly accurate measure of the progress attained is not now available. The lack of this information is an embarrassing commentary on medical and public health interest in the diagnosis and reporting of communicable diseases. Perhaps it is equally so on our own failures to stimulate this quality to a higher level or to develop more sensitive techniques than now exist for the micromeasurement of malariousness. At present levels, the thick film, although the best tool we have, is just simply not suited as a rapid survey instrument. However, conceding some differences of opinion as to the actual dimensions of current malaria prevalence, I think we all agree that it is now even less than the all-time low level reached in 1943.

To broaden the panorama for a moment, we must not lose sight of the fact that today malaria remains the Number One health problem of the world. To what extent, in keeping with the "one world" concept, are our responsibilities extra-continental, and how far do they extend? The answer must consider both our economic interests and our moral obligation to build better world health. What is the actual hazard of importing foreign strains of malaria? What effect is this likely to have on the problem of practical eradication in this country? How much of an organization, and what type must we maintain to prevent reactivation or reintroduction—or to cope with them promptly and effectively if they do occur? How much attention should we give to the promotion and how much can we afford to invest in development of improved malaria control practices in our neighboring nations as an additional safeguard in preventing resurgences of the disease in this country? These are some of the issues to be resolved. Work on them is now underway. Our favorable

malaria experience following World War II should not beguile us into discounting potential dangers or in failing to provide effectively against them. Certainly there can be no disagreement with the view that we should support all phases of research in order to hasten solution of these problems.

Short of a major development in chemotherapy or the perfection of a diagnostic tool, sensitive, specific, and practical for wide application, it is my opinion that primary dependence must be placed in "shoe leather" epidemiology to find the areas where active malaria transmission still occurs. Defining these areas, confirmed parasitologically and entomologically will give intelligent direction to our attack against parasite and vector. Inter-state coordination of such a campaign, while difficult, can be achieved. Of all elements, the clear delineation of remaining foci is by far the most difficult and, I believe, at the moment the most important.

Still mobilized is the most competent anti-malarial machine ever produced. It draws added strength from the well-coordinated team approach of medicine, biology, and engineering. The forces at the federal, State and local levels are in reasonable phase. Work at the Tennessee Valley Authority and elsewhere has clarified issues to minimize the malaria potential on impounded waters. Attitudes of the allied interests in surface waters are more nearly synchronized. We are moving toward the eradication goal. The National Malaria Society represents the malaria intelligence of the nation. These are the forces which must assume the responsibility for outlining strategy and for assuring positive action over the next few years—years that may be the critical years.

POTENTIATION OF THE CURATIVE ACTION OF 8-AMINOQUINOLINES AND NAPHTHOQUINONES IN AVIAN MALARIA

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The use of combinations of chemotherapeutic agents against infections has not received widespread attention or usage. In malaria therapy quinine has been administered concurrently with at least two 8-aminoquinolines. When combined with quinine, pamaquine at levels which often produce toxic symptoms, does possess curative activity against vivax malaria. Pentaquine also has exhibited curative activity against vivax malaria when administered concurrently with quinine. It seems quite possible that a combination of therapeutic agents of distinctly different chemical structures and acting upon different vital phases of the life cycle of the parasite or the host-parasite relationship would effect a greater response than could be accounted for by a purely additive response of the individual agents. This report deals with an apparent potentiation of the curative antimalarial action observed in *Plasmodium cathemerium* infections of the duck with combinations of two 8-aminoquinolines (pamaquine and pentaquine or SN 13,276[2]) and three naphthoquinones[3] (SN 5949, SN 12,320 and SN 13,936).

In previous reports (Walker, Stauber and Richardson, 1946 and in press) the curative activity of pamaquine against the 3 T strain of *Plasmodium cathemerium* infections in the duck was established. Other 8-aminoquinolines have also been found to possess a curative action (Richardson and Walker, 1946). The curative action of pamaquine has been further demonstrated by Dearborn and Marshall (1946) and Kelsey, Oldham and Gittelson (1946) in *P. lophurae* infections of the duck and chicken, respectively. During the routine screening of drugs for curative action a naththoquinone identified as SN 12,320 was found to possess activity (Walker and Richardson, 1945). SN 12,320 has been described by Fieser (1945) as one of a mixture of four isomers, the mixture being identified as SN 8557. Recently, Gingrich et al. (1947) have reported that SN 8557 produced cures in canaries with various types of *P. cathemerium* infections.

In general the technique as described in the preliminary report (Walker, Stauber and Richardson, 1946) was followed except that subinoculation was not used as a criterion of cure. Ducks 10 to 12 days old and weighing approximately 150 grams were divided into groups of 10 to 20 each. Each duck was inoculated intravenously

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[2] Serial numbers assigned to drugs in "Survey of Antimalarial Drugs, 1941–45."

[3] We are greatly indebted to Dr. M. Leffler of Abbott Laboratories and Dr. L. F. Fieser of Harvard University, who supplied the naphthoquinones for this study. SN5949 = 2-hydroxy-3-(2-methyl octyl)-1,4-naphthoquinone; SN 12,320 = 2-hydroxy-3-[3-(decahydro-2-naphthyl) propyl]-1,4-naphthoquinone; SN 13,936 = 2-hydroxy-3-[3-(p-phenoxy phenyl) propyl]-1,4-naphthoquinone.

with 500 million parasitized erythrocytes per kilogram of body weight. Therapy by the drug-diet technique was begun 16–18 hours before inoculation and was continued for 6 days following inoculation. Three or 4 diet-levels were used for each drug tested. The ducks were observed for a total of 23 days after therapy was discontinued with blood smears being made and examined for parasites once each week. After the blood smears were made on the 23rd post-inoculation day each duck was re-inoculated with 500 million parasitized cells per kg. of body weight and smears were made and examined 3 days later. The criteria of cure were taken as (1) the absence of parasites in the weekly blood smears made after therapy was discontinued until the day of re-inoculation and (2) the production of a significant level of parasitemia in the treated ducks upon re-inoculation as indicated from smears made 3 days later. The latter is a more critical criterion as indicated in our report (in press).

TABLE 1

Curative Action of Pamaquine Naphthoate, Pentaquine and SN 12,320 in P. Cathemerium *Infections of the Duck*

DRUG	DIET LEVELS	CURES			
		Expt. 1	Expt. 2	Expt. 3	Total
	per cent				*per cent*
Pamaquine naphthoate	0.00125	0/14	0/11	—	0 (0/25)
	0.0025	2/12	1/13	—	12 (3/25)
	0.005	9/13	5/14	2/12	41 (16/39)
	0.01	11/12	5/8	—	80 (16/20)
Pentaquine	0.00125	0/8	—	—	0 (0/8)
	0.0025	3/13	—	—	23 (3/13)
	0.005	4/15	—	—	27 (4/15)
	0.01	4/11	—	—	36 (4/11)
SN 12,320	0.075	—	2/14	5/14	25 (7/28)
	0.15	—	5/10	—	50 (5/10)
	0.25	—	—	5/9	56 (5/9)
	0.30	—	8/8	—	100 (8/8)

The curative activities of pamaquine, pentaquine and SN 12,320, as determined individually, are shown in Table 1 which constitutes data obtained in three experiments with pamaquine serving as a standard in each. When a dosage-response curve was plotted from the data, the 100 per cent curative level (CD_{100}) for pamaquine was found to be 0.015 per cent in the diet. The data indicate that SN 12,320 has about $\frac{1}{20}$ the activity of the 8-aminoquinolines. These diet-levels which brought about 100 per cent cures or approached that value always produced some toxicity. In the case of pamaquine a marked reduction in food intakes together with a number of deaths was observed with a diet of 0.01 per cent. On a diet of 0.3 per cent of SN 12,320 seven ducks of fifteen died during, or within two days following, therapy.

The curative activity of combinations of SN 12,320 and pamaquine is shown in Table 2 and constitutes results obtained in experiments 4 and 5. The ratio of the

diet-level of SN 12,320 to that of pamaquine in the combined therapy experiments was varied from 7.5 to 120 in order to study the effect of different combinations on the curative activity in ratios both above and below the ratio of their individual activities. The results when compared with those in Table 1 indicate a potentiation of the curative action. For example, the combination of 0.0375 per cent SN 12,320 and 0.00125 per cent pamaquine citrate, which represent $\frac{1}{8}$ and about $\frac{1}{10}$ of the CD_{100}'s of these drugs, respectively, and which individually would produce no (or few) cures, has produced a 100 per cent curative effect. If the action were merely additive, an effect would be anticipated not to exceed 0.2 ($\frac{1}{8} + \frac{1}{10}$) or approximately $\frac{1}{5}$ of the ducks would be expected to be cured. Therefore, the observed effect would constitute a 4–5 fold potentiation. If one took into account the results obtained with the combination of 0.0188 per cent SN 12,320 and 0.00062 per cent pamaquine citrate, then an 8-fold potentiation was obtained. Since the curative levels of these drugs administered separately were near the toxic level, this potentiation becomes important in that cures may be obtained at levels well below those which cause toxic symptoms.

TABLE 2

Curative Action of Combinations of Pamaquine Citrate and SN 12,320 in P. Cathemerium *Infections of the Duck*

DIET LEVELS		CURES/NO. DUCKS
SN 12,320	Pamaquine Citrate	
per cent	*per cent*	
0.0188	0.00062	9/9†
0.0188	0.00125	9/9†
0.0188	0.0025	8/8†
0.0375	0.00031	7/9†
0.0375	0.00062	6/8†
0.0375	0.00125	14/14*
0.0375	0.0025	12/12*
0.075	0.00062	13/13*
0.075	0.00125	9/9*
0.075	0.0025	12/12*
0.075	0.005	14/14*

* Experiment 4.

† Experiment 5.

In another experiment using 10 ducks in each group pentaquine was substituted for pamaquine, and SN 5949 and SN 13,936 for SN 12,320 with similar evidence of potentiation of the curative action. The results are shown in Table 3. Despite the fact that pentaquine as indicated by the results in Table 1 was probably less effective than pamaquine in its curative action, approximately the same degree of potentiation was obtained when combined with SN 12,320. Because of insufficient drug supply of SN 5949 and SN 13,936 the curative activity of these drugs was not individually determined, so that the degree of potentiation with these naphthoquinones and their

relative activity in relation to SN 12,320 in the combined therapy studies could not be accurately determined. SN 12,320 and SN 5949 have Q values (quinine ratios) of 4 for their suppressive activity against *P. cathemerium* as reported in the Survey of Antimalarial Drugs (Vol. II, pp. 120 and 115). From unpublished data SN 13,936 was found to have a Q value of 1. Taking into account the comparative suppressive activities of these three naphthoquinones, the limited data in Table 3 do seem to indicate some potentiation of the curative activity. It appears significant that pentaquine may replace pamaquine and other naththoquinones replace SN 12,320 with no marked change in the degree of potentiation. Based on these limited observations it is suggested that these two types of antimalarial agents are synergistic in their curative action against *P. cathemerium* infections in the duck.

TABLE 3

Curative Action of Combinations of Several Naphthoquinones with Pamaquine and Pentaquine in P. Cathemerium *Infections of the Duck*

DRUG LEVELS					CURES/NO. DUCKS
Naphthoquinones			8-Aminoquinolines		
SN 5949	SN 12,320	SN 13,936	Pamaquine	Pentaquine	
—	0.0375	—	—	0.00062	8/8
—	0.0375	—	—	0.00125	9/9
—	0.075	—	—	0.00125	8/8
—	—	—	—	0.00125	0/8*
—	—	0.1	—	—	0/8
—	—	0.1	—	0.00062	9/10
—	—	0.1	—	0.00125	7/8
—	—	—	0.00125	—	0/25*
0.1	—	—	0.00125	—	4/4

* From Table 1.

EFFECT OF COMBINATIONS ON SUPPRESSIVE ACTION

In an attempt to explain this action, combinations of SN 12,320 and pentaquine were assayed in an experiment for suppressive activity in *P. cathemerium* infections according to the G-4 testing procedure as described in the Survey of Antimalarial Drugs (Vol. I, 483). Ducks of the same age and approximate weight as used in the curative test were divided into groups of 4 or 5 each and inoculated in the same manner as mentioned above. Therapy was carried out similarly but continued for only 4 days after inoculation, which corresponds to the peak of parasitemia in untreated controls. Averages were made of the parasite levels of the ducks on each of the 3 or 4 diet-levels of the drugs on the 4th day after inoculation and expressed as per cent of the average parasite level of the untreated controls. The results of the suppressive experiment as shown in Table 4 when plotted as dosage-response curves indicate that pentaquine with an approximate ED_{50} level of 0.000125 per cent in the diet is about

40 times as active as SN 12,320. With this ratio of the suppressive activities maintained in the diet levels the results obtained with combinations of SN 12,320 and pentaquine reveal little more than an additive effect on the suppressive activity. For example, on the diet containing 0.0047 per cent SN 12,320 which produced a 50 per cent reduction in parasite count from the untreated controls and 0.000125 per cent pentaquine which alone produced a 70 per cent reduction, a reduction in parasite

TABLE 4

Suppressive Activity of Pentaquine and SN 12,320 and Combinations of These Drugs against P. Cathemerium *Infections in the Duck*

DRUG	DIET	PARASITEMIA (PER CENT OF UNTREATED CONTROLS)
	per cent	
SN 12,320	0.0024	100
	0.0047	50
	0.0094	4
	0.0188	0.1
	0.0375	0
	0.075	0
Pentaquine	0.000062	100
	0.000125	30
	0.00025	0.3
	0.0005	0
	0.001	0
SN 12,320 Pentaquine	0.0012 0.000031	100
SN 12,320 Pentaquine	0.0024 0.000062	90
SN 12,320 Pentaquine	0.0047 0.000125	8
SN 12,320 Pentaquine	0.0094 0.00025	0
SN 12,320 Pentaquine	0.0188 0.0005	0

count of 92 per cent was obtained. With the next lower diet of 0.0024 and 0.000062 per cent of SN 12,320 and pentaquine, respectively, which levels individually had no suppressive activity, only a slight suppressive activity (10 per cent reduction in parasite count) was observed. If the combination of these drugs were effective in producing a potentiation of the suppressive action of the same order as the curative action, a significantly greater response would have been obtained. The fact that these combinations in approximately the same ratio of diet levels produce a potentiation of the curative action while causing little or none in the suppressive

action against the same parasite in the same host seems rather unusual and suggests two distinct types of action.

It was realized that the procedure used in these and previous studies was only qualifiably designated as a curative technique, since therapy was begun before the infection had become well established in the host. However, Gingrich (1947) has reported that with the same parasite but in a different host the results with treatment begun the day of inoculation have corresponded with results obtained in latent or chronic infections. On the other hand, it must be pointed out that the infection employed is a virulent one in the duck and if permitted to go untreated for 6–8 days will result in a mortality of 50 to 75 per cent.

TABLE 5

The Effect of Delayed Therapy on the Curative Action of SN 12,320 and Pentaquine and Combinations of SN 12,320 and Pentaquine in P. Cathemerium *Infections of the Duck*

DRUG	DIET	DEATHS DURING THERAPY	CURES/NO. DUCKS
	per cent		
SN 12,320	0.075	7	6/9
Pentaquine	0.01	19	0/1
SN 12,320 Pentaquine	0.0375 0.005	9	8/9
SN 12,320 Pentaquine	0.0375 0.0025	5	12/13
SN 12,320 Pentaquine	0.0188 0.005	3	10/15
SN 12,320 Pentaquine	0.0188 0.0025	3	9/16

EFFECT OF DELAYED TREATMENT ON CURATIVE ACTION

In an attempt to determine the value of combined therapy of SN 12,320 and pentaquine in well-established infections, 144 one-week old ducks were inoculated and left untreated for 6 days. On the 4th day after inoculation the average parasitemia was found to be 42.3 per cent parasitized erythrocytes. Before the ducks could be divided into groups and therapy begun, 16 had died and the remainder showed varying degrees of anemia and lethargy. Twenty ducks were put on each diet but because of their depressed state the consumption of food was low in many instances with the result that a large number of deaths occurred within several days after the initiation of therapy. The results of this experiment (Table 5) indicate that SN 12,320 has a curative action. When compared to the results shown in Table 1, it appears on the basis of the one diet-level that SN 12,320 may be slightly more effective against well-established (or chronic) infections.

It has been observed that the consumption of food in normal ducks is markedly

reduced on a diet of 0.01 per cent pentaquine. It is felt that this fact in conjunction with the depressed state and condition of the ducks at the time therapy was begun resulted in the mortality on this diet as shown in Table 5 in which only 1 duck survived. This result prevents any accurate measure of the degree of potentiation of the curative action observed with combinations of SN 12,320 and pentaquine. Also it was observed that on the diets containing 0.005 per cent pentaquine and because of condition of the ducks, a definite decreased food intake, and consequently low drug intake, was obtained. However, it is evident that the combination of these drugs has a marked curative action.

DISCUSSION

In the treatment of human malaria various combinations of quinine, quinacrine and pamaquine have been employed. The association of quinine with pamaquine has been reported to be efficacious in treating benign tertian and quartan malaria. It is known that toxic symptoms are often encountered during intensive therapy in man with pamaquine and its combinations, so that the margin of safety is rather narrow.

SN 8557 which is considered a mixture of 4 isomers of which SN 12,320 is undoubtedly the most active in avian malaria, has shown activity against blood-induced vivax malaria (Survey of Antimalarial Drugs, Vol. 1, 272). In this infection SN 8557 has been given a quinine equivalent of less than 0.15. If the results just presented on the potentiation of the curative action with 8-aminoquinolines and naththoquinones against *P. cathemerium* in ducks do carry over into the human species of plasmodium, the recommended dose of the 8-aminoquinolines (and naphthoquinones) might be reduced at least 4 times and still a maximum effect would be anticipated with combinations of these agents.

From the limited number of 8-aminoquinolines and naththoquinones used in these studies no statement can be made about how inclusive the potentiation is between these two distinctly different types of drugs or about a possible explanation for this effect. Since the suppressive action of the drug combinations is not potentiated, the possibility of an explanation on the basis of a change in degradation or elimination as a major factor is quite unlikely. The existence of exoerythrocytic forms of the 3 C strain of *P. cathemerium* in canaries is generally accepted, and so the existence of this tissue phase of the life cycle in ducks is indeed a possibility. In producing an enhancement of the curative action these combinations of 8-aminoquinolines and naphthoquinones may be particularly active against this phase of the life cycle of the parasite or against some vital factor in the host-parasite relationship.

SUMMARY

The curative action of pamaquine, pentaquine and the naphthoquinone, SN 12,320, against *P. cathemerium* infections in the duck is established. When pamaquine or pentaquine was incorporated into the diet together with SN 12,320 (or with two other naththoquinones, SN 5949 and SN 13,936) an apparent potentiation of the curative action was observed. With a similar ratio of diet-levels the suppressive activity of combinations of these drugs was not potentiated, which indicates a different type of

action, probably on a different phase of the life cycle of the parasite or of the host-parasite relationship.

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TRAINING OPPORTUNITIES WITH ARMY MEDICS IN GERMANY

The U. S. Army Medical Department announces the availability of opportunities for advanced training and experience in the various special fields of medicine and surgery in overseas Army hospitals. These hospitals are registered with the American Medical Association, and this training may be acceptable by the specialty board as part of the period usually required to be spent in limited practice and experience prior to admission for examination. Interested members of the medical profession who have completed the formal training requirements for certification in one of the special fields are eligible to apply for these positions.

As of January 1, 1948, 108 openings were available and will be kept open until filled. They include all branches of medicine. Also 21 openings in general surgery and 5 in urology are being considered. Positions offered will be in various station hospitals in Germany.

The applicant may avail himself of this training for periods of one, two or three years. Those applicants who are selected, and who hold reserve commissions in the Medical Corps, will usually be recalled to active duty in the highest grade attained prior to release from previous active service. Those who do not hold such reserve commissions will be tendered a reserve commission in the Medical Corps in keeping with their age, years of professional experience and prior service in any branch of the Armed Forces. Prior military service is not required. Individuals who are members of the U. S. Naval Reserve must transfer to the Army Reserve before being called to active duty. Families of married applicants will be allowed to accompany them to the place of duty. Suitable quarters are available. Families of individuals who do not declare their desire to serve for periods to exceed one year cannot be transported at Government expense.

Eligible physicians are invited to communicate with The Surgeon General, U. S. Army, Washington 25, D. C., for further information.

MALARIA CONTROL TRENDS ON IMPOUNDED WATERS OF THE TENNESSEE VALLEY

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The impoundage of water in the southeastern United States is followed inevitably by the production of *Anopheles* mosquitoes and a rise in malaria prevalence unless preventive or remedial measures are undertaken. As early as 1910, controversy, apparently due to increased prevalence of malaria, arose following the impoundage of a comparatively small water supply reservoir on the Cahaba River in Central Alabama (Hazelhurst and Kiker, 1934). Little was then known of the factors influencing the prevention of increased anophelism from impoundment of flowing streams. Impoundage of the Hales Bar project on the Tennessee River without prior clearance of the basin was effected in the winter of 1911–1912. The testimony of old inhabitants of this area indicates that the population in the mile zone suffered severely from mosquito biting and malaria and that litigation followed in 1913. In 1914, a large artificial lake, the basin for which was only partially cleared, was impounded on the Coosa River in Alabama. The records show that a sharp increase of malaria occurred in the population bordering the lake during the first year of impoundage.

These and many other unfortunate experiences with malaria epidemics following the impounding of reservoirs for a variety of purposes occurred in many widely scattered areas in earlier years and the foregoing instances are cited merely as examples.

Regulations governing the impounding of water were adopted in 1923 by Alabama acting on the advice of the United States Public Health Service and subsequently readopted in 1927 to meet a legal technicality after an epidemic of malaria had occurred in the population living near the Gantt Reservoir which had been impounded without clearing. These regulations as repassed have served as a pattern for many other states and are so basically sound that only minor changes would be recommended today. Their main objective has been to provide naturalistic or biological control of the malaria transmitting mosquito through the development of a clean, water surface. The method of approach is through thorough reservoir preparation, adequate water level management, and effective shoreline maintenance.

Coincidentally, more effective antimosquito measures, particularly for the larval stages, have been evolved until now it is entirely feasible to develop impounded water projects without imposing an undue hazard upon inhabitants of adjacent territory. Nevertheless, eternal vigilance is still the price of effective malaria prevention as is well demonstrated by a number of epidemics within the past decade. For example, 120 cases of malaria are said to have followed the flooding of an old drainage way at Camden, New Jersey; a similar outbreak occurred at Aurora, Ohio, after the damming of a small creek in a new residential subdivision; increased prevalence as far north as Minnesota has been associated with impoundages on the Upper Mississippi;

and in the South there was an increase in prevalence following impoundage of the Santee-Cooper development.

DISTINCTIVE FEATURES OF MALARIA CONTROL ON IMPOUNDED WATER

Consideration of public policy imposes a definite responsibility upon operators of impounded water projects for the control and prevention of malaria among the inhabitants within flight range of such reservoirs. This responsibility is unique, for it is not comparable to most other public health problems, nor is it similar in principle to other problems associated with the management of multipurpose impoundages. Here an arbitrary segregation of populations living within one mile of the reservoirs must be treated in an entirely different way from their neighbors, for the owner of the impoundage cannot be held responsible for malaria transmitted by mosquitoes produced in breeding grounds outside the reservoir. But the fact that populations beyond flight range may have no protection against malaria does not relieve the owner of responsibility for protection within flight range, since the situation established by the impoundage is an artificial one, deliberately created, in contrast to natural breeding areas existing beyond the influence of the reservoir. Hence, prevalence of malaria beyond the zone of flight of the vector is an improper basis upon which to compare prevalence within flight range of the reservoir, and thus an unsound basis for the evaluation of programs.

A different group of distinctions arises from the fact that the character and composition of the malaria control and prevention problem changes fundamentally with the biological maturation of particular reservoirs and the extent of the water control system on particular streams. If mosquito control has been built into each reservoir as it was prepared for impoundage, if proper provision for water level manipulation has been built into the dams, and if there is a controlled system for the management of stream flow, assets for the control of breeding exist which are not usually available at natural sources of mosquito production. For example, the scope and type of marginal growth can be substantially limited by appropriate manipulation of water levels, flotage can be stranded above normal pool levels, larvae can be stranded by cyclical variations of level, and shorelines can be adjusted to present contours unfavorable for mosquito production. Finally, it is a basic concept that, in a coordinated chain of multipurpose reservoirs, the change of water level in a particular lake influences actually or potentially the mosquito production factor of every other lake.

TRENDS IN TVA'S MALARIA CONTROL PROGRAM

Stream flow in the Tennessee River is more completely controlled than in any other river on earth. A system of tributary and main river reservoirs reaches from headwaters to mouth of a river system draining a basin upon which more rain falls than upon any area of like size in the United States. These reservoirs are bounded by shorelines exceeding 10,000 miles in length, the normal summer levels of which at the dam sites vary from 359 to 1,959 feet above mean sea level. Prime purposes are flood control, navigation, and production of electric power, all requiring management of water. Within this complex of requirements, provision for water level manipulation in the interest of mosquito control has been so completely integrated that the

needs of malaria control for water level variation are being met almost in their entirety. With the fulfillment of collateral requirements relative to shoreline improvement, subsidiary water management, and growth control, the time is almost within view when routine use of repetitive measures will have practically disappeared from the scheduled program. That this trend is indeed a fact is well illustrated by comparison of experience during the last three mosquito breeding seasons as presented in Table I. It will be noted that substantial decreases in all units of repetitive operations—a more stable index than costs—have occurred. Admittedly, the season of 1945 was atypical, but impoundage of the main stream was completed in that year; hence, it is the starting point of a fully integrated system of water control. The consistent decline in the extent of operations, together with the effectiveness of control as indicated by average female *Anopheles quadrimaculatus* counts, lends considerable significance to the comparison.

TABLE I

Comparison of Malaria Control Operations by Years (1945–1947) for Season May through September

DESCRIPTION	1945	1946		1947		
	Total	Total	Per cent reduction 1946 over 1945	Total	Per cent reduction 1947 over 1946	Per cent reduction 1947 over 1945
Man hours	258,003	187,596	27.3	127,586	32.0	50.5
Boat hours	20,337	4,983	75.5	1,593	68.0	93.2
Plane hours	526:05	395:15	24.9	254:20	35.6	51.7
Car and truck miles	392,143	294,807	24.8	205,902	30.2	47.5
Larvicidal treatment:						
Miles	9,035.0	2,831.8	68.7	1,676.2	40.8	81.4
Acres	92,619	86,323	6.8	32,254.9	62.6	65.2

NOTE: 1945 is an atypical year, breeding having begun much earlier than normal. These are preliminary figures, but the error is not of a magnitude that would significantly affect the trend.

Average station counts of female *Anopheles Quadrimaculatus* by years were: 23, 5.5, and 3.5 respectively.

Assuming that appropriate features for water level management as it pertains to mosquito control have been included in the design of dams, the malaria prevention program of TVA breaks down into the following details:

Reservoir preparation must be as carefully planned and executed as is the dam itself, for upon preimpoundage planning depends both the economy and effectiveness of the postimpoundage malaria control operations. Complete removal of all timber and brush that would pierce the water surface is a sine qua non and special types of clearance, including flyways for airplanes, selective clearing in the flood surcharge zone, and erosion clearing, are also essential under special circumstances. The second basic measure in preparation is that of subsidiary water control and shoreline adjustment. For this, the most precise topographic mapping and very detailed work in biology and engineering are absolute essentials. Not less than four years of careful work by the field and central staff was required for planning and executing the preimpoundage work in Kentucky Reservoir (Gartrell and Kiker, 1947; Bishop and Gar-

trell, 1944). Included in that work are such features as diking and dewatering of large areas of shallow water, major filling and deepening projects, marginal drainage, and the purchase of easements preventing human habitation of areas not amenable to other methods of control. Not all reservoirs will require such a complex system, but practically every impoundage will need marginal drainage and major or minor shoreline modification, since relatively minor capital investments prior to impoundage will usually affect the economics of postimpoundage operations out of all proportion to the capital expenditures. For example, it is believed that the cost of postimpoundage control operations in the Kentucky Reservoir is about half of that which would be required without the permanent works installed during construction.

After impoundage, *water level management* is the sheet anchor of mosquito control. Within a system of reservoirs such as exists in the Tennessee Valley, there is maximum opportunity to utilize this procedure. Through biological investigations and field appraisal, an improved and integrated system of water level management providing complete control of both mosquitoes and the vegetation which supports their development has been gradually evolved for TVA reservoirs. In the earliest days, reliance was placed upon spring surcharge and cyclical fluctuation or, where these were not possible, upon seasonal recession. Today, on the majority of the main river impoundages, a four-phase water level management program is in effect. The first involves the utilization of a flood surcharge during which time (late winter or early spring) the water level is brought up to the maximum elevation in the flood surcharge zone for a brief period in order to strand the winter's accumulation of drift and flotage. The second phase is maintenance of a relatively constant pool level at the normal maximum summer elevation from the beginning of the early spring growth period until the beginning of moderate production of *Anopheles quadrimaculatus*. This limits invasion of the zone of fluctuation by marginal vegetation, thus providing a clean shoreline when the water is drawn down by cyclical fluctuation and seasonal recession later in the season. The third phase is weekly cyclical fluctuation without seasonal recession beginning with moderate production of *Anopheles quadrimaculatus* —usually between the middle of May and the first of June—and ending with the beginning of heavy production of *A. quadrimaculatus* about July 1. The fourth and final phase of water level management is a combination of seasonal recession of approximately $\frac{1}{10}$ foot per week with the regular weekly cycle of fluctuation. Seasonal recession insures that, at the low level of the fluctuation cycle, the water will be drawn far enough out of the advancing band of marginal vegetation to provide adequate control of *A. quadrimaculatus*. In general, it appears that 2 feet of recession is sufficient for this purpose. When combined with 1 foot of cyclical fluctuation, the result is an over-all recession of 3 feet below the normal pool level (Hess and Kiker, 1944). In storage reservoirs where cyclical fluctuation is not possible, the normal operating requirement of spring filling followed by straight seasonal recession must be relied upon for control. Finally, in certain of the smaller main river reservoirs, it may be possible to accomplish effective water level management by increasing the amplitude of cyclical fluctuation without seasonal recession as, for example, on Wilson Reservoir where the level is raised and lowered about 2 feet each week.

Shoreline maintenance and improvement after impoundage is an absolute essential to

successful control by water level management. Maintenance is largely a matter of supplementary vegetation control in order to hold intersection line values to a minimum. Shoreline improvement involves adjustments of a permanent nature similar to measures used in preimpoundage preparation but which either could not have been effectively planned prior to impoundage or which later became possible through improved techniques and methods.

Annual shoreline conditioning for vegetation control in the zone of fluctuation on TVA reservoirs is utilized to increase the effectiveness of larvicides and, where possible, to limit their application. Early procedures depended largely on hand methods, but operations were mechanized and area burning has been used in some places. Chief emphasis is on removal of water tolerant woody species (e.g. willow and button ball) and stiff stemmed annuals. Recurrent cutting first by hand and later mechanically, together with some use of conventional herbicides, proved moderately successful in the control of true aquatic species; but it has now been established that 2,4-D is highly effective for control of many such species, and application of this chemical by airplane is being developed (Hall and Hess, 1947). Of incidental though significant value in biological control of vegetation is marginal grazing. Its usefulness has been increased on TVA shorelines by contour fencing and grazing rotation.

Permanent shoreline improvement in the main river reservoirs is going forward as a result of the successful experience with the Kentucky Reservoir and has been extended to include deepening and filling to eliminate many small areas. All such projects have been quite successful in permanently eliminating breeding surfaces, but construction on the impounded projects has heretofore been restricted to a brief period in the fall when the lakes were low. During the current season, techniques for temporary diking and dewatering have been developed, and, by this means, construction work is now possible during a considerable portion of the year (Simms and Kiker, 1948).

At the moment, the malaria control staff and the field engineers are engaged in the preparation of plans for an accelerated program of permanent improvement, principally deepening and filling, which is designed to build out permanently the mosquito potential from all significant breeding areas in TVA reservoirs. The first major construction on this program was done this year on Hales Bar Reservoir, which extends for 40 miles, has 150 miles of shoreline and 6,100 acres of water surface. All significant mosquito breeding areas—about 265 acres—are being eliminated by deepening and filling. Mosquito production potential will be so limited that, with cyclical fluctuation of 2 feet, no further need for repetitive larvicidal measures is anticipated. This appears to be the first reservoir of considerable size in which mosquito breeding has been completely built out of the project through permanent works. The program calls for similar adjustments on other lakes of the system.

Insecticidal control of mosquito breeding, especially since the development of the newer mosquitocides, has a place in any malaria control problem involving impounded waters. During the early history of impoundment, it is an indispensable measure and the degree to which permanent measures succeed this repetitive measure depends upon many factors, including the ingenuity of a malaria control staff and the willingness of management to undertake improvements requiring capital investments. The

trend of the use of larvicides on TVA lakes is well illustrated by the fact that, in earlier years, some 60% of the budget for control operations was spent for this measure, while at present the comparable figure is less than 16%. The decline in costs is, of course, due both to increased effectiveness of larvicidal methods and decrease in the area where the measure is used.

In 1934, major reliance was placed on oil larviciding by boat which, on Lake Wilson in 1926, cost $29,000 (1926 Annual Report, Alabama State Health Department). Realizing that such methods would be impractical and uneconomical on the larger TVA lakes then in prospect, the distribution of larvicidal dusts by airplane was studied. In 1937—when Wheeler Reservoir was impounded—the routine application of Paris green by airplane was established and, for several years, constituted the most important element of larvicidal attack. Refinements in equipment and distribution made this measure most useful, but an inherent weakness was inability to penetrate heavy vegetation and forest canopies effectively. Experimental work with DDT was begun in 1943, a pilot-scale demonstration developed in 1945, and routine application of thermal aerosols by airplane established in 1946. Today, DDT as an aerosol or fine spray applied by airplane is used to the practical exclusion of all other methods of larviciding. It is a much more flexible operation than the use of Paris green, since one load suffices for an entire morning of work and—due to better penetration of vegetation—is applicable to many areas over which, in earlier years, airplane distribution could not be used. Further studies are in progress and may lead to the use of fine mist-like sprays of larger particle size than are being secured with thermal aerosoling.

During the early years of impoundage when, under prevailing circumstances, adequate control could not be secured by more fundamental methods, it was found that mosquito proofing, reinforced by shoreline conditioning and water level management, could be used to advantage in limited areas. Annual maintenance of mosquito proofing proved increasingly costly. With the development of DDT residual spray techniques and after careful study of their applicability under our circumstances, residual spraying of all structures of premises was substituted for mosquito proofing. It now appears that this method with applications at the rate of 200 mg. per square foot offers more protection against malaria transmission than mosquito proofing with its inherent limitations. The change in method was made with the full endorsement of appropriate state health departments (Hinman and Cutkomp, 1947).

Definition of the need for and results from the application of repetitive malaria control techniques has, in the Tennessee Valley as elsewhere, been based upon three criteria—larval inspections, adult inspections, and an analysis of the incidence of the disease. The level of larvicidal control is still reported in terms of numbers of anopheline larvae per dip, and the inspection technique has changed but little during the past few years, although Hess (1940) has devised a screen dipper to sample one square foot of area which gives greater uniformity of results. Due to the high degree of proven effectiveness and the consistency of results from the use of DDT as a larvicide, larval inspections are now confined to spot checks. Similarly, methods of sampling for adult anophelines have undergone little change and depend upon the

use of livestock shelters adjacent to the reservoir, supplemented by keg traps (Smith 1942) and in a few instances culverts or others suitable structures. A parasitemia survey each fall is a program item. Originally confined to school children, these surveys are now made on a house-to-house basis since, with declining prevalence, schools afford an unreliable sample. Additionally, the collection of samples is confined to those portions of the reservoir with the highest mosquito production potential and this limitation has substantially reduced the number of specimens essential in establishing parasitemia levels. Several years ago, as malaria morbidity declined, survey methods were supplemented by the use of nurses for investigation of all reports of illness resembling malaria, the reports being secured through specific inquiry by malaria control personnel in the field. This work is closely coordinated with and under the auspices of state and local health agencies, and the service has the double purpose of contributing to the measurement of morbidity and of identifying individual cases of malaria earlier in order that adequate therapeutic and prophylactic measures may limit the possibility of transmission. For example, identification of a particular case might immediately lead to residual spraying of the home of the individual and, if necessary, to similar treatment of adjacent premises. Conceivably, it might lead to the intensification of larvicidal activities. With low incidence, the health agency is increasingly concerned with the individual case as a potential epidemic focus and thus the problem is essentially the prevention instead of control of the disease.

The *economic trends* of TVA's malaria control program provide substantial evidence of the tendency away from repetitive measures for mosquito control as well as of refinements in these measures as such. There are approximately one-third of a million people residing within flight range of the reservoirs and the shorelines are visited annually by several million others. The extent and complexity of the mosquito potential on TVA reservoirs has rarely, if ever, been equaled by a single operation in this country. The problem, therefore, has been to devise methods of control of this potential which are fully effective and at the same time within rational limits of cost. The following items indicate some examples of progress:

In 1935, about 54,000 gallons of oil and 31,000 pounds of Paris green were applied on Lake Wilson, the smallest reservoir in the system, at a cost of $25,000 with comparatively poor results in terms of mosquito control. In 1937, a combination of cyclical fluctuation with seasonal recession was initiated with the result that less than 5,000 gallons of oil and 4,000 pounds of Paris green were applied with a net saving in costs of $20,000 and substantially more effective mosquito control. Further modifications in 1943 resulted in increased economy, and, at present, mosquito production is held within very narrow limits at very low costs.

Progressive improvement and refinement of water level management practices have substantially limited growth invasion of the fluctuation zone and currently are resulting in an economy of approximately $260,000 annually on 12,000 acres of shoreline through limiting the need for growth removal and the use of larvicides.

Application of larvicides has progressed through stages of boat and hand work to airplane dusting with Paris green and airplane aerosoling with DDT. Unit cost of the latter method is about one-third that of Paris green dusting, and methods cur-

rently in use are costing $450,000 per annum less on 10,000 acreas of breeding surface than were earlier methods.

Permanent shoreline improvements in the Kentucky Reservoir include diking and dewatering of 5,000 acres on which current costs are approximately $15 per acre, which compares to approximately $25 per acre under conventional but less effective antilarval methods. In the same reservoir, deepening and filling eliminated the breeding potential of 1,600 acreas in toto, thus saving $40,000 annually in control by conventional methods.

Repetitive machine cutting in aquatic growth control costs approximately $22.50 per acre as compared to current costs at $8 per acre through application of 2,4-D.

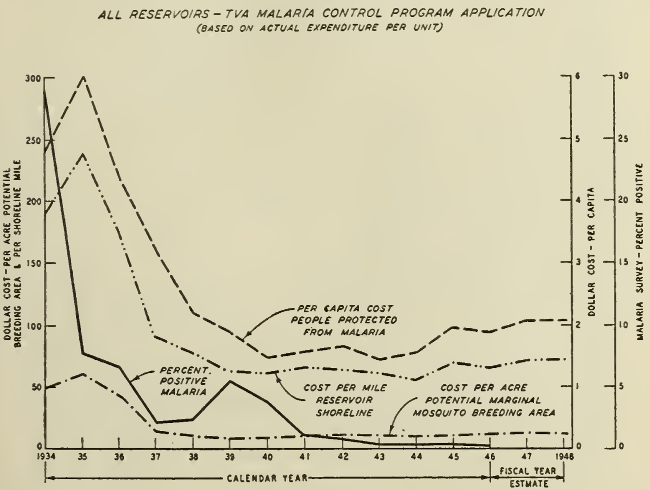

Fig. 1

Six hundred acres of lotus are now controlled at a cost of $9,000 per annum less than that of earlier methods.

In addition to the initial expenditures for mosquito proofing, annual maintenance charges reached an average of $12 per house for which residual spraying of premises has been substituted at a cost of about $5 per house. Aggregate cost of protection for 1,400 homes is $10,000 less per annum than was the cost under mosquito proofing.

Unit costs when analyzed provide additional evidence of progressive change in the character of malaria control activities. Reservoir clearance and preparation practices, together with maintenance work, have limited the area of mosquito breeding potential in TVA reservoirs to the 3-foot zone lying immediately below normal pool level which totals about 58,000 acres. Three unit costs, based respectively on

miles of shoreline, acres of potential breeding areas and number of residents within flight range, can be used in studying cost trends of program application throughout the period during which additional reservoirs were being added. Figure 1 illustrates these trends unadjusted to changing dollar values. Additionally, it shows the decline in parasitemia rates as determined by annual surveys of populations within flight range. Figure 2 presents the same trends adjusted to the wholesale price index issued by the United States Department of Labor, assuming that the 1933 dollar remained stable throughout the period. It will be noted that the curve downward is sharper than in the figure based on unadjusted values. In Figure 3 actual expendi-

ALL RESERVOIRS—TVA MALARIA CONTROL PROGRAM APPLICATION
(COSTS ADJUSTED TO 1933 BASE = $1.00)

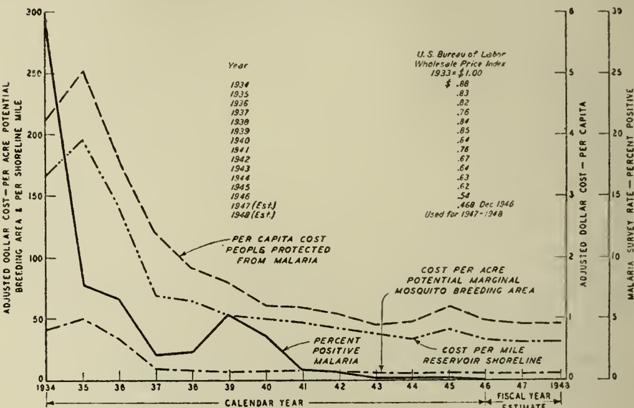

FIG. 2

tures for field application of malaria control measures on TVA reservoirs from 1934 to 1946 are plotted and for comparison there is shown graphically for the same period the hypothetical expense of the program had field operations continued to cost $50 per acre of potential breeding area. The comparison is based on unadjusted costs. A similar comparison utilizing miles per shoreline is even more spectacular, but introduces variables unsuitable for evaluation in so brief a discussion.

TREND OF MALARIA INCIDENCE

The trend of malaria incidence (Figure 1) in the Tennessee Valley closely parallels the general experience of malaria parasitemia in the Southern United States. But the fact that the extensive impounding of water without adequate control measures may readily reverse such a trend cannot be overemphasized. Experience in many areas of the country, cited earlier in this discussion, affords abundant evidence of the

almost inevitable rise in malaria incidence in projects where inadequate provision has been made for control measures. It will be observed that, as measured by surveys of populations adjoining TVA reservoirs having the highest mosquito potential and covering a period from 1934 to the present, the decline in incidence has been so substantial as to indicate an extremely low level of parasitemia. It is thought that the term "malaria prevention" better describes the present status of TVA's work than does the term "malaria control."

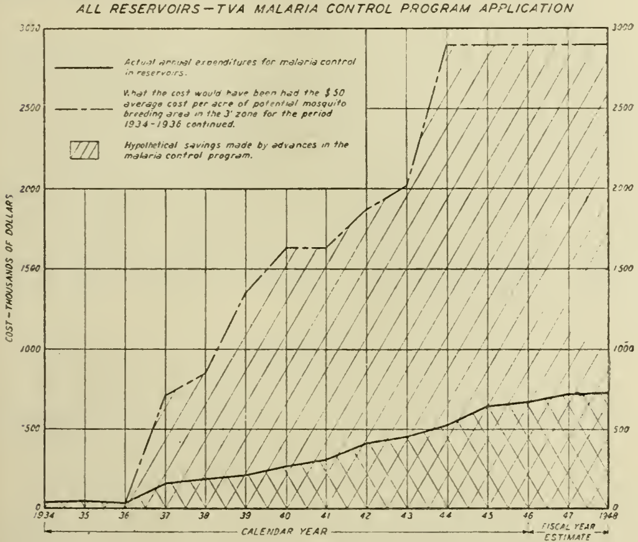

FIG. 3

THE CURRENT OUTLOOK

The first stage in the evolution of malaria control on the Tennessee River system is nearly complete and, currently, it appears that the whole program is in a state of rapid transition from principal reliance upon temporary repetitive measures to primary dependence upon permanent measures which establish and maintain naturalistic control. The single major item of the present schedule yet to be completed is the elimination of all remaining mosquito breeding areas of consequence, principally by deepening and filling procedures. This method is already through the experimental and pilot-scale stages of development, having been extensively tested in one reservoir and applied to the whole of another. Work on other reservoirs is in an advanced state of planning, and it is clear that the entire undertaking can be financed

through savings anticipated from the elimination of repetitive measures. When work is completed, repetitive use of such measures as larviciding and residual spraying will have become things of the past. Their usefulness in the control of emergencies will, of course, remain, but their role will be similar to that of fire control facilities. Additionally, close and expert epidemiological, biological, and engineering surveillance must be maintained over the entire system of reservoirs in order to confine essential work within rational economic limits and maintain operations that are fully effective in sustaining the interplay of natural influences necessary to prevent anopheline production.

It is believed that the experience of the TVA, now in its fifteenth year, has demonstrated the feasibility, in this country, of developing multipurpose water control projects involving large river systems without associated increases in malaria transmission. It seems apparent that this statement is true irrespective of biological and topographic differences between river systems, for conditions in the Valley cover almost the whole range of possible variations in circumstances significantly influencing mosquito production. If a well planned and carefully evaluated program is not built into the design, construction, and operating stages of each project, the results may well be disastrous. If adequate measures for prevention and control are provided, potential hazards can be eliminated or minimized. Hence, while in this country there are specialized approaches to the problem of controlling the malaria potential of impounded waters, no national plan for malaria eradication need anticipate insoluble difficulties in connection therewith.

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STUDIES ON IMPORTED MALARIAS

7. The Parasitological Pattern of Relapsing *Plasmodium vivax* in Military Patients[1]

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Earlier reports in this series (Young, *et al.*, 1945, 1946a and b; Moore, *et al.*, 1945) have demonstrated the ability of the principal malaria vectors of this country to transmit foreign malarias from returned military personnel showing clinical relapses. Upon determining that clinical relapsing cases readily infected the mosquito vectors, it was desirable to determine if the human carriers of malaria could infect mosquitoes at times other than during clinical relapses, viz., during asymptomatic parasitic relapses (when parasites were present in the blood stream without clinical symptoms).

During the study of this problem it became apparent that the relapsing parasites were found in several patterns in relation to the clinical manifestations of the disease. The delineation of these parasitic patterns by the study of a large group of patients is the object of this report.

The present study was conducted at Moore General Hospital and extended from October, 1944 until March, 1946. During the 18 months, over 700 patients with *vivax* malaria were studied in whom over 1,000 individual clinical attacks were observed. Of these, more than 200 were "delayed" primary attacks, occurring after termination of atabrine suppression. The size and nature of the study can best be demonstrated by tabulation (Table 1).

METHODS

Patients suspected of having malaria were admitted to the malaria wards. After diagnosis was proved by the finding of parasites in the blood smears, quantitative parasite determinations were made daily or more often until three consecutive negative smears were obtained, this usually following treatment. Counts referred to in this study as fever threshold counts are the first quantitations after the patients were admitted to the ward. These usually followed the first paroxysm by less than 12 hours.

After the treatment of clinical attacks, most patients were transferred to convalescent wards and were followed with twice-weekly smears until relapse or until discharge to duty (usually after 120 or more days of observation without clinical at-

[1] Contribution from the Imported Malaria Studies program of Malaria Investigations, National Institute of Health and the Office of Malaria Control in War Areas, United States Public Health Service, Columbia, S. C.

[2] Moore General Hospital made available the relapsing cases, as well as the laboratory quarters, for which we express our appreciation. We are also indebted to the Office of The Surgeon General, United States Army, whose active interest made the program possible.

tack). Personnel limitations necessitated the study of some patients only during their clinical attack. Asymptomatic patients found to have parasites during the twice-weekly follow-up were not transferred to malaria wards, but were required to report for temperature readings three times daily and were examined for parasites daily.

To determine parasite density, a minimum of 0.1 cmm. of blood was examined unless parasite density was very high. During the initial phases of the study quantitations were made by determining the ratio of parasites to leucocytes. This method was abandoned early in the study for a modification of the direct method described by Earle and Perez (1933).

Patients were considered symptomatic only when oral temperatures exceeded 100°F.

TABLE 1

Scope of study of foreign Plasmodium vivax *in military personnel*

THEATER	TOTAL NUMBER OF PATIENTS	NUMBER OF OBSERVED CONSECUTIVE ATTACKS WITH NUMBER OF PATIENTS UNDER EACH CATEGORY						TOTAL NUMBER OF OBSERVED ATTACKS
		1	2	3	4	5	6	
Pacific	563	361	126	56	14	4	2	869
Mediterranean	155	125	25	5	—	—	—	190
CBI	11	8	1	2	—	—	—	16
Caribbean	2	2	—	—	—	—	—	2
Total	731	496	152	63	14	4	2	1,077

OBSERVATIONS

Clinical relapse attacks. Over 800 clinical relapses were observed in this study. These relapses occurred both in patients whose primary attacks (delayed) had been observed at this hospital and in patients returning from overseas with malaria histories.

The first warning of an approaching clinical episode in those patients under observation before the onset of the first paroxysm was often the presence in the blood of small numbers of malaria parasites. In our study 77.2 per cent of the relapse attacks in patients under observation (351 cases) were first detected by the finding of parasites in the blood smears before the first fever occurred. Undoubtedly this percentage would have been increased had smears been made on a daily rather than twice-weekly basis, this being logical because of high fever threshold values at relapse. These parasitemias are henceforth termed "preclinical asymptomatic parasitemias."

On the average the first parasites were found 3.5 days before the first paroxysm of the relapse. Ordinarily, there was a steady increase in parasite number until the fever threshold level was reached. In a few instances extended asymptomatic parasitemias culminating in clinical relapse occurred; some upset of the immune balance must have allowed the parasites to increase to symptom-producing level after having been held in check for days.

The median fever threshold parasite count for over 800 relapse attacks was 3200

per cmm. (mean, 6300 per cmm.).[3] The median for Pacific cases was 2952 per cmm. (mean, 6030), for Mediterranean cases was 3836 (mean, 7250). Table 2 summarizes the counts at symptomatic relapse by theater and by relapse number, grouping the attacks in order to increase the number of patients in each category. No significant variation in parasite level was found between early, middle, and late relapses in either the Pacific or the Mediterranean group. The Mediterranean relapse cases showed significantly higher parasite fever threshold counts than the Pacific group ($p = 0.017$).

To further test the conclusion above that no significant change occurred from early to late relapses, fever threshold counts on successive relapses were tabulated for 265 cases. Counts at first observed relapse had a median value of about 4000 per cmm.

TABLE 2

Median and mean parasite counts at symptomatic relapse grouped according to number of relapses patients had undergone. The grouping has the effect of increasing the number of patients in the various categories

THEATER	NUMBER OF RELAPSES			
	1–5	6–10	11 and over*	All
Pacific				
Median count‡	2752	3182	2808	2952†
Mean count‡	5850	7150	5630	6035
Number cases	446	108	105	659
Mediterranean				
Median count‡	3516	3790	4320	3836†
Mean count‡	6830	7330	7428	7249
Number cases	40	90	55	185

* Few patients reported over 20 relapses.

† The difference ($p = 0.017$) between these values is considered as significant.

‡ Parasites per cmm.

Counts at second observed relapse had a median value of 3900. The difference is insignificant.

The same tabulation of consecutive attacks for the same patients does demonstrate a factor of importance; a significant although moderate degree of positive correlation between counts during successive episodes was noted ($r = +.4$). Thus, patients with high counts during one episode were likely to have high counts at a second and vice versa.

Routine counts made on 844 relapse attacks showed gametocytes to be present in 35.2 per cent. The above percentage refers to male gametocytes since only this form is easily recognized in the thick film which was used for most of the counts. Table 3 summarizes the gametocyte counts by theater and by relapse number.

Pactific cases showed gametocytes in only 29.4 per cent of 659 attacks against 55.7 per cent for 185 Mediterranean attacks. Analysis shows this difference of 26.3 per

[3] Fever threshold counts are not normally distributed, consequently both median and mean counts are given; in our opinion the median is the best representation of central tendency.

cent to be highly significant. Median gametocyte count for Mediterranean cases was also higher being 110 per cmm. compared with 80 per cmm. for the Pacific group.

The apparent lower gametocyte counts in later relapses for the Pacific cases was not significant. In the group of Mediterranean cases the later attacks had significantly lower gametocyte counts ($p = .011$ when Mediterranean relapses 1 through 5 were compared with relapses 11 and over).

In a series of 265 patients studied during consecutive attacks no significant difference in gametocyte incidence was noted from the first observed to the second observed relapse attack. In this series 56 patients showed gametocytes during both attacks, 139 during neither attack, and 70 showed sexual forms during one attack and not during the other. Thus 195 of the 265 patients were consistent which would make it appear that some patients are more likely to produce gametocytes than others and therefore more likely to be efficient infectors of mosquitoes. This is confirmed by the observation that of 90 patients found with gametocytes during the first clinical

TABLE 3

Proportion of clinical attacks during the course of which male gametocytes were noted. Grouped according to theater and the number of relapses the patients had undergone

THEATER	DELAYED PRIMARY ATTACK	NUMBER OF CLINICAL RELAPSES			
		1–5	6–10	11 and over	Total relapses
Pacific					
Number cases	200	446	108	105	659
Per cent with gametocytes	22.5	29.6	36.1	21.9	29.4
Mediterranean					
Number cases		40	90	55	185
Per cent with gametocytes		75	56	49	55.7

attack, 56 or 62.2 per cent had gametocytes during the second (as opposed to 34 per cent of original sample with gametocytes). This higher incidence would rarely result from chance (p below 0.00006).

To determine if there was any relationship between the height of parasitemia at onset of symptoms and the likelihood of subsequent relapse, data on 200 Pacifi theater patients who had been observed after relapse for 120 days or until relapse again occurred were tabulated. Table 4 shows that similar proportions relapsed in the groups with different parasite levels. A gradual increase in the proportion relapsing was noted as parasite level increased but none of these values differed significantly from any other.

Delayed primary attacks. Over 200 patients were observed through the course of a clinical attack reported by them to be their first. These attacks in individuals without malaria history are termed "delayed" primaries since exposure to infected mosquitoes obviously occurred when under suppressive atabrine discipline (or perhaps rarely quinine). In many instances the history of the patient indicated a definite locality of origin for the infection but often the patient had been in several malarious areas and only a guess could be hazarded. With very few exceptions, the

delayed primaries studied were from the Pacific theater of operations. The Territory of New Guinea probably contributed the greatest number of infections.

Delayed primary attacks occurred on the average 49.1 days after discontinuation of suppressive atabrine. One hundred cases analyzed gave a median value of 41 days, the central half occurring between 27 and 58 days. Extreme intervals between discontinuation and onset were 7 and 167 days. The persistence of a therapeutic atabrine level in the blood doubtless explains the delay until several weeks. The variation in interval after discontinuation of atabrine may be due to the relationship of the time of drug discontinuation to the not yet fully explained but apparently cyclic invasion of parasites to the blood from the exoerythrocytic hiding places.

The median value of the first parasite count after onset of fever for the delayed primary group was low being 870 per cmm. for 197 cases (mean 3900 per cmm.). We suspect that in this group are included some patients who had had previous unrecognized primaries because we found a group of 50 naturally induced Pacific primaries had a median fever threshold count of less than 100 parasites per cmm. Under

TABLE 4

Relationship between parasite level at onset of symptoms and proportion of patients subsequently relapsing (Pacific theater only)

PARASITE LEVEL AT RELAPSE	NUMBER OF PATIENTS	RELAPSED SUBSEQUENTLY	
		Number	Per cent
Parasite count below 1000 per cmm.	34	24	71
Parasite count between 1000 and 2952 per cmm.	53	41	77
Parasite count between 2952 and 5000 per cmm.	37	30	81
Parasite count over 5000 per cmm.	76	63	83

combat conditions oftentimes vague illnesses did occur and frequently hospital facilities were not available for accurate diagnosis. Furthermore, atabrine discipline was likely to be most lax and bodily resistance least during the exposure necessitated by a campaign.

In the case of the relapse attacks discussed in a previous section, we believe that the first parasite count after onset of symptoms gives a fair representation of the fever threshold count. This is probably not true of the counts on the delayed primary group. On some occasions initial symptoms occurred during the course of the patient's "overseas" furlough, these symptoms persisting undiagnosed until the return of the patient to the hospital. Unfortunately for study, many of the patients were on furlough four to eight weeks after return from abroad for Army policy was to allow these returning patients to take leave as soon as possible after return to the United States.

Even though the patients with delayed primary attacks were present in the hospital at the time of onset of symptoms, delay in reporting them often occurred. Most of the patients were on dermatological, surgical, or gastro-enterological wards and, having had no previous experience with the disease, did not report their malaise promptly.

To eliminate this factor of delay, 63 cases, in which it was fairly certain symptoms were reported promptly, were selected and the median value of this group was 450 parasites per cmm. This is significantly lower than the median value of 2952 per cmm. for Pacific relapse attacks. For contrast 17 delayed primary cases, in which parasite counts did not follow promptly the onset of symptoms, had a median value of 1856 per cmm.

A group of 65 patients was observed during the delayed primary attack and during a subsequent relapse. Of these 44 had a higher parasite count at relapse despite the fact that these patients were carefully watched for reappearance of symptoms. Chi-square test shows this to be significantly different from the expected ratio if delayed primary attack and first relapse were similar. Median value for the 65 delayed primaries was 730 parasites per cmm.; median counts for the corresponding 65 relapses was 1980 per cmm.

The entire group of delayed primaries had gametocytes in 22.5 per cent of the attacks. This percentage was reduced to 17.5 per cent for the group in which it was certain counts followed soon after the onset of symptoms. This percentage is considerably higher than the percentage found in the naturally induced group referred to above just after onset of symptoms (2.0 per cent). It seems probable that the delay in reporting and the possible admixture of relapse attacks in the delayed primary group may be responsible for the relatively high incidence of gametocytes just as it seemed responsible for the higher total parasite counts. The values for the group of delayed primaries were lower than the incidence for Pacific relapses but the difference was only of borderline significance (p = about .05).

Interval between clinical episodes. The mean interval between clinical episodes in 292 instances was 61.1 days. All patients were observed for 120 or more days after each clinical attack unless relapse occurred and the cumulative frequency curve to time of relapse (Figure 1) would indicate that most of the relapses had occurred by the end of this period. Consequently, the true mean would be somewhat but not greatly larger than the figure given above, due to the non-inclusion of the few attacks with extremely long interval periods. Median value for time to relapse was near the mean, being 59 days. Length of interval as used by us is measured from the onset of one attack to the onset of the next.

The interval between relapses varied according to the drug regimen used in therapy, being shortest for quinine and longest for chloroquine. As was brought out by Most *et al.* (1946), who studied the same group of patients, this variation in interval is likely related to the degree of persistence of a therapeutic drug level in the tissues of the body.

After treatment of the clinical attacks, low level, asymptomatic, usually transient parasitemias were noted in a small proportion of the cases; this type of parasitemia is henceforth termed in this paper as "interval asymptomatic parasitemia". Two hundred and sixty-two intervals were studied with twice-weekly smears and 12.2 per cent showed this phenomenon (Table 5). In most cases temperatures were taken on patients that showed such parasites to determine if sub-clinical response to the infection was occurring and in the instances studied no such sub-clinical response was noted.

Proportions showing the interval parasitemia were so nearly similar for the two major theaters that these are not discussed separately. The parasitemias were on

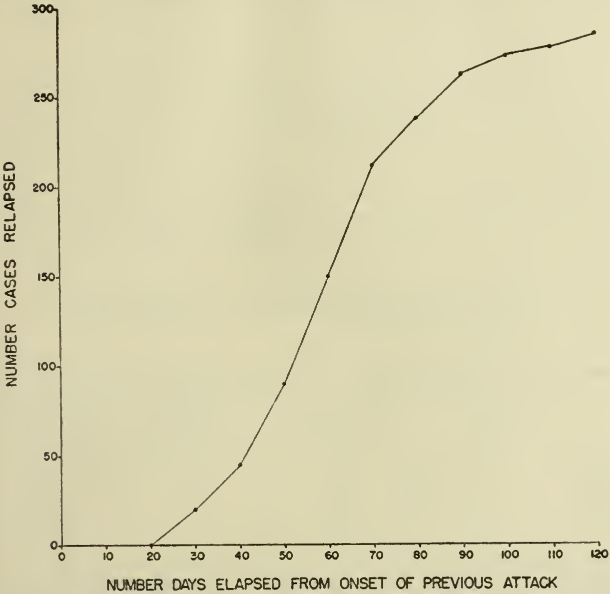

FIG. 1. Cumulative frequency graph of interval to relapse. Interval in these cases is measured from the onset of the nth attack to the onset of the nth + 1 attack.

TABLE 5

Incidence of interval asymptomatic parasitemias in 263 patients. Blood smears taken twice weekly

THEATER	NUMBER INTERVALS OBSERVED	NUMBER WITH INTERVAL PARASITEMIA	PER CENT WITH INTERVAL PARASITEMIA
Mediterranean	32	3	9.4
Pacific	231	29	12.6
Total	263	32	12.2

the average first noted 56.1 days after the onset of the preceding clinical episode. This corresponds so closely to the mean time to relapse that the coincidence suggests that these parasitemias are homologous to clinical relapses, the parasites being held in check and finally eliminated by the immune mechanism of the human host.

The interval asymptomatic parasitemia endured on the average for 12 days but the cases actually observed varried from one to 62 days. In over two-thirds of the cases the patient was continuously positive until the negative period preceding relapse. The mean time from the end of the interval parasitemia to the following clinical relapse was 23.8 days.

Thus, from the onset of the interval asymptomatic parasitemia to the onset of the following clinical episode was on the average 35.8 days. This might lead one to believe that a further invasion of the blood from the hypothetical exoerythrocytic situations occurred at this time. The 35-day time interval is not greatly different from the interval between attacks when the first attack is terminated by a quickly eliminated drug such as quinine.

Parasite level during the interval parasitemia was lower than that found in the same patient at the following clinical relapse. Median highest level during the asymptomatic period was about 270 as compared with a value near 3000 for the following clinical episode.

The occurrence of gametocytes during the interval asymptomatic parasitemia is discussed in an accompanying paper (Eyles, Young, and Burgess 1948).

TABLE 6

Incidence of terminal asymptomatic parasitemias in 314 patients observed over a 120-day period after last clinical expression. Blood smears taken twice weekly

THEATER	NUMBER PATIENTS OBSERVED	NUMBER WITH PARASITEMIA	PER CENT WITH PARASITEMIA
Mediterranean	95	24	25.3
Pacific	219	55	25.1
Both Theaters	314	79	25.2

Observations during 120 day period after last clinical expression of the disease. Three hundred and fourteen patients were followed with twice-weekly blood smears for 120 or more days after their last observed clinical episode (usually 120 days plus length of treatment period which varied with drug). Referring again to the cumulative frequency graph (Figure 1), it will be seen that the curve becomes almost asymptotic after 120 days. Though a few relapses occur after this length of time, the number is sufficiently small that the data on a group of several hundred patients should indicate expectations during the final stages of the disease.

Our data indicate that the course of the disease in these patients usually ended with the treating of a clinical attack. However, a significant proportion, 25 per cent, were shown to have asymptomatic parasite activity after the last clinical episode, what we shall designate as "terminal asymptomatic parasitemias" (Table 6). Since proportions were similar from the two theaters, they are discussed together.

Terminal asymptomatic parasitemias were first observed on the average about 80 days after the last observed clinical attack (compare a period of about 60 days to relapse). Median day to parasite occurrence (77.5 days) was close to the mean. The mean duration of these parasitemias was about 44 days but this figure is deceptive because of the great range (1 to 186 days) and the fact that many of the parasitemias

had not terminated at the end of the observation period (nearly 35 per cent were positive less than two weeks before the end of observation).

Duration of the parasitemia as used in this text refers to the number of days elapsing between the first and last positive smear. Nearly half of them persisted for more than a month. Parasitemias were both remittent and intermittent; only those of short duration were continuously positive.

The level of parasitemia was variable. In general the maximum levels occurred during the first days of the terminal parasitemia. Occasionally a second or third lower peak was attained and in the long duration parasitemias which were nearly continuous the parasitemia was remittent but gradually decreasing in magnitude. Levels attained by the asymptomatic parasitemias were usually only one-fourth to one-half the levels noted in the same patients at the time of previous clinical attack.

Patients who showed these asymptomatic terminal parasitemias were required to report for temperature measurements three times daily. A lag in initiating temperature determinations of from one to two days often followed the first appearance of parasites and there is some possibility that minimal clinical symptoms occurred, but these, if present, were in no case of sufficient severity that the patient reported for sick call. Several of the parasitemias started while patients were on furlough; consequently, no temperature record was available. These patients reported no attack and brought back smears taken twice-weekly while away from the post.

TABLE 7

Prevalence of parasitemia in 200 patients observed an average of 4 months each

	PACIFIC THEATER	MEDITERRANEAN THEATER	BOTH THEATERS
Number patients observed	150	50	200
Number attacks	232	61	293
Mean number of attacks per patient	1.6	1.2	1.5
Mean days with parasitemia	16.8	12.9	15.8
Mean days with parasitemia accompanied by symptoms	3.9	2.8	3.6
Mean days with asymptomatic parasitemia	12.9	10.1	12.2
Preclinical	5.7	4.5	5.4
Interval	1.5	0.8	1.3
Terminal	5.8	4.8	5.5

In two instances patients placed in the category of those with terminal asymptomatic parasitemias were detected with slight fevers. In both of these cases levels of parasitemia similar to those attained in the previous clinical attack were reached for a short time. In both cases temperatures did not rise as high as 102°F. and fell immediately without treatment.

Relative prevalence of parasitemia. To determine the proportion of time that malaria patients exhibited parasitemias, a group of 200 patients were followed for an average of slightly over four months with blood smears taken no less frequently than twice weekly. The data thus secured are shown in Table 7.

During the four-month period, parasites were present in the peripheral blood of Pacific theater patients on the average for 16.8 days or 13.0 per cent of the time.

During most of this time (12.9 days) the patients were asymptomatic; this time of parasitemia without symptoms amounting to 10.0 per cent of the four-month observation period. On the average both the preclinical and the terminal asymptomatic parasitemias persisted longer than the clinical parasitemia. It should be pointed out that patients were usually treated within 24 to 48 hours of the first symptoms.

Parasites were present in the blood of Mediterranean patients on the average for 12.9 days or 10 per cent of the four-month period. The fact that Pacific cases relapse more frequently than Mediterranean accounts for some of the difference since the Pacific cases were observed to average 1.6 attacks each in the four-month period contrasted to an average of 1.2 attacks for the Mediterraneans. Chance probably is responsible for the small differences in prevalence of asymptomatic parasitemia.

Observations of untreated attacks. A small group of patients volunteered to deny themselves of treatment; this was suggested with the view that by suffering longer, immunity might reach a height sufficient to prevent further relapse.

Of ten patients originally in this group, three were treated because of the severity of the continued attack. One of the seven patients that succeeded in going through with the clinical phase of the attack without treatment was treated at his own request several months later although he was asymptomatic at that time. All seven of the patients had terminal asymptomatic parasitemias after the end of the last clinical period. Only one had clinical recurrence after becoming asymptomatic for over a few days. Four representative cases are discussed below and are shown graphically in Figure 2. Parasite counts were made twice weekly or more often, except when the patient was on furlough.

Patient 1. White male, age 25, Mediterranean theater. Had had 5 previous attacks beginning July, 1943. Observed attack began October 22, 1944. Paroxysms were quotidian for 22 days when they ceased. No fever or other symptoms, except minimal temperatures on 29th, 30th, and 32nd days, were noted until the 48th and 50th day of observation when temperatures over 104° F. were measured and patient chilled. Patient was then asymptomatic until the 86th day of observation. Light chills were recorded the 86th and 90th day; fever at 103.7°F. and heavy chill on 88th day. Patient was then observed for seven months with no clinical activity; parasite activity was at first continuous during the seven months but short periods during which parasites could not be demonstrated became increasingly frequent toward the end of the observation period. Level of parasitemia became pregressively lower until at the end of observation counts of less than 100 per cmm. were usual (Figure 2).

Patient 2. White male, age 29, Pacific theater. Had had eight previous attacks starting in May, 1944. Observed attack began October 22, 1944. Patient had paroxysms at irregular intervals until the 30th day of observation (eight paroxysms during 30-day period), only one of the paroxysms being accompanied by more than 104°F. fever. Patient was clinically inactive until 138th day at which time he requested treatment due to continuous unwell feeling which was most likely neurotic. This patient had a terminal parasitemia at first continuous but punctuated toward the last by long periods during which parasites were not detected in the blood. It is worthy of note that after treatment patient had a further asymptomatic parasitemia two months later which lasted seven days beginning the 200th day of observation.

Patient 3. White male, age 25, Pacific theater. Had had ten previous attacks. After observed attack began October 26, 1944, patient had three tertian paroxysms. After the last paroxysm patient became free of parasites on the 15th day of observation. Starting on the 106th day of observation he showed small numbers of parasites (less than 10 per cmm.) for 13 days. Subsequent to this, patient was free of parasites until observation ceased on the 165th day.

Patient 4. Colored male, age 26, Mediterranean theater. Had had eight previous attacks. Observed attack began September 7, 1944, and only a single paroxysm was suffered. Patient was with-

out parasites on 6th day of observation but parasites without symptoms appeared on 16th day. Patient had low parasitemia (below 50 per cmm.) until 21st day at which time he went on furlough Subsequently asymptomatic parasitemias appeared for short periods during which low densities

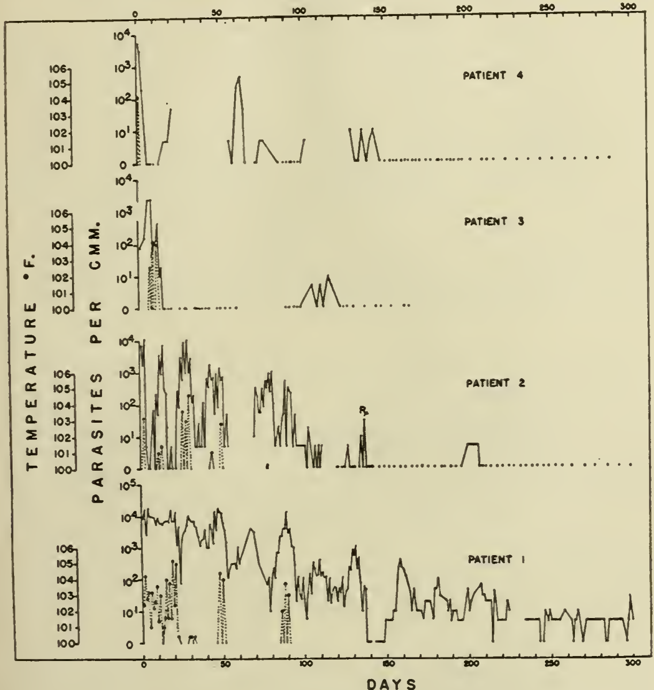

FIG. 2. Pattern of parasite and clinical activity in 4 patients who volunteered to deny themselves treatment. The patients had experienced between 5 and 10 clinical attacks before the beginning of this observation. Blood smears were taken twice weekly or more often except when patient was on furlough, which period is indicated by blank spaces. Dots on base line indicate that no parasites were found on blood smear. The parasite density is shown on a logarithmic scale, viz., $10^1 = 10$, $10^2 = 100$, $10^3 = 1000$, etc.

●——● Parasites per cmm. O- - - -O Temperature °F

prevailed. After the last parasites were noted on the 144th day of observation, patient was free of parasites until observation ceased on the 287th day.

Although the group of ten patients is too small to indicate probabilities in a large group, it can be seen that the parasitological behavior of untreated patients varies greatly. Of our ten patients, at least half had extended clinical activity despite the

fact that several had had a large number of previous attacks (this includes the three patients whom it was necessary to treat). The other half of the group, however, had spontaneous clinical remissions after a very small number of paroxysms.

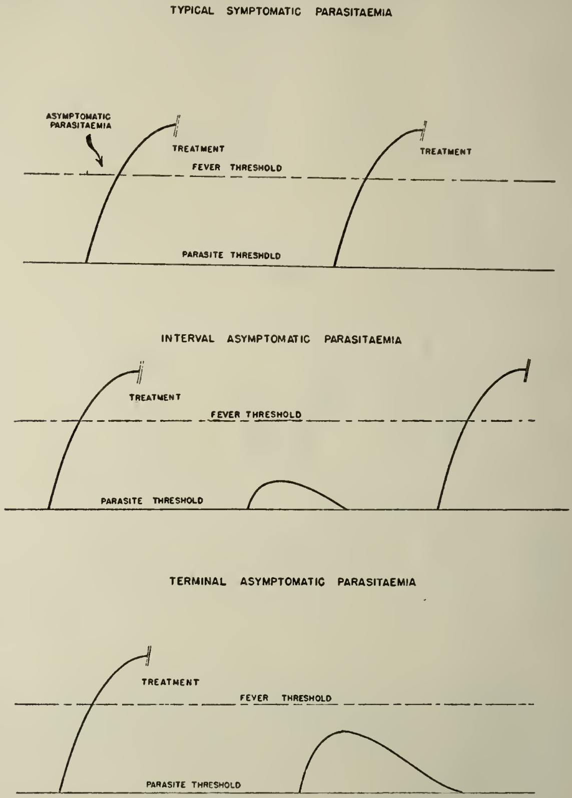

FIG. 3. Characteristic patterns observed in military personnel infected with *Plasmodium vivax* malaria.

Behavior after spontaneous termination of symptoms also was varied. Two of seven patients followed had persistent parasitemias of relatively high level; whereas, five showed only sporadic parasite activity during the terminal observation period.

It is of interest to note that the remittent parasitemia of patient 1 showed maxima about every 22 days (mean of 22.1 ± 0.9 days).

DISCUSSION

The previous sections have described findings based on the observation of *Plasmodium vivax* in a large group of military patients. It is possible to relate these findings and outline several characteristic patterns of parasitological behavior. It should be emphasized that these patterns were subject to much variation and intercombination.

The most frequent pattern was characterized by treated clinical relapse followed by treated clinical relapse (Figure 3, upper graph). Asymptomatic parasitemia was present only during a few days just preceding the onset of relapse symptoms (preclinical asymptomatic parasitemia). Termination of the disease was sudden; after a last treated clinical episode, no further parasites were found.

A similar pattern increasingly frequent toward the end of the war and subsequently was characterized by a delayed primary attack with a low parasite level which, after treatment, was followed by a variable number of relapses with higher parasite levels. The increased frequency of the delayed primary was probably due to improved atabrine discipline; during the early war days most patients had primary attacks overseas.

A significant proportion (about 25 per cent) of the patients showed a variation of this pattern in which the termination of the disease came as a terminal asymptomatic parasitemia. Other patients aborted symptoms without treatment; these patients also had terminal asymptomatic parasitemias (Figure 3, lower graph).

A small number of patients, about 12 per cent, showed parasite activity between clinical episodes, "interval asymptomatic parasitemias" (Figure 3, middle graph). These parasitemias were usually transient and were characterized by low parasite densities.

Despite the fact that the classification of patients by theater very likely results in the lumping of observations on a number of different strains, several consistent differences between attacks in persons from the Pacific and Mediterranean theaters were noted. Higher parasitemia levels characterized the Mediterranean relapse attacks and gametocyte incidence was significantly greater. As was noted by Most *et al.* (1946) the Mediterranean cases showed a much smaller proportion relapsing. Since Most and his associates studied the same group of patients under consideration here we have not included our observations on relapse. We did attempt to correlate relapse with parasitemia level but found that patients with high and low parasite levels relapsed in similar proportions.

The rate at which the different types of parasitemias infect mosquitoes is considered in an accompanying paper (Eyles, Young and Burgess 1948).

SUMMARY AND CONCLUSIONS

This report has presented data based on the observation of over 700 patients through more than 1000 individual clinical attacks of malaria. A substantial proportion of these patients were examined by blood smears during the interval between successive clinical attacks and for a 120-day period after the last clinical expression of the disease.

Summarized findings were as follows:

1. About three-quarters of patients undergoing relapse attacks showed parasites in the peripheral blood before the onset of symptoms; this preclinical asymptomatic parasitemia endured on the average 3.5 days.

2. Median parasite level at clinical relapse for Pacific cases was 2952 per cmm. Median parasite level at relapse for Mediterranean cases was significantly higher being 3836 per cmm.

3. No significant difference between parasite level during early clinical relapses and late relapses was found.

4. Patients with high or low parasite densities during one clinical episode tended to have high or low counts, respectively, during a second.

5. Patients with high or low parasite counts at one relapse relapsed again in similar proportions.

6. Male gametocyte incidence was significantly higher in Mediterranean than in Pacific cases.

7. Patients with or without gametocytes during one relapse were likely to be with or without, respectively, during a following relapse attack.

8. Delayed primary attacks from the Pacific theater were found to occur on the average 7 weeks after the discontinuation of suppression.

9. Parasite level at most of the delayed primary attacks was significantly lower than during relapse.

10. Gametocyte incidence during the delayed primary was lower than at relapse but significance could not be demonstrated.

11. Mean interval, without regard to type of the drug used, from the onset of one clinical episode to the onset of a second was 61.1 days. Cumulative frequency study indicated that most relapses had taken place by 120 days.

12. Most patients showed no parasite activity during the interval between clinical attacks. About 12 per cent showed transient, low level, interval asymptomatic parasitemias, occurring on the average about 56 days after the onset of the preceding clinical episode. These parasitemias persisted on the average 12 days, the next clinical relapse following about 24 days later.

13. About 25 per cent of the patients had terminal asymptomatic parasitemias. These occurred on the average 80 days after the onset of the last clinical episode and persisted for an average of 44 days. Parasitemias were remittent or intermittent and levels were much lower than levels that provoked symptoms earlier in the same individuals.

14. Terminal asymptomatic parasitemias of varying intensity persisted in untreated patients after spontaneous termination of symptoms.

15. Malaria parasites were present in the peripheral blood of the Pacific malaria patient 13 per cent of the time and in Mediterranean patients about 10 per cent of the time. In both groups 75 to 80 per cent of the time of parasitemia was asymptomatic.

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EFFECT OF 3,3′ METHYLENEBIS (4 HYDROXYCOUMARIN) "DICUMAROL"[1] ON *P. LOPHURAE* INFECTION IN DUCKS

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Ducks infected with *P. lophurae* were given 3,3′ Methylenebis (4 Hydroxycoumarin) and it was observed that the development of the parasitemia was inhibited. The results of these observations are reported.

METHODS

Young white Pekin ducks were inoculated intravenously with blood from donor birds infected with *P. lophurae.* The degree of parasitemia was determined by counting the number of parasitized cells per 500 red blood cells in the peripheral blood. The blood smears were made by puncturing a vessel in either the leg or the web of the foot. The smears were stained with a combination of Giemsa's and Wright's stains. Standard methods were used for counting the red blood cells. Hayem's fluid was used as the diluent.

Dicumarol was given by mouth. The quantity and the time of administration are given in the different experiments. The amount of dicumarol given to birds with malaria varied in the different experiments. However, the experiment was controlled always by giving an equal amount of the drug to ducks of the same age.

EXPERIMENTAL

Effect of Dicumarol on the Parasitemia in Ducks Infected with P. lophurae

In this experiment 40 ducks 24 days of age were used. Ten of these were given malaria, 15 were given malaria and dicumarol while 15 were given only dicumarol. The parasitemia was followed in 5 ducks from each of the 2 groups with malaria. The average degree of parasitemia is shown as Experiment 1 in Fig. 1. The degree of parasitemia is much less in the group given the dicumarol than it is in the non-treated group. The time at which death of the birds occurred is given in Table 1 as Exp. 1.

In a second experiment 35 ducks 15 days of age were used. Twenty of these were given malaria, 10 were given malaria and dicumarol and 5 were given only dicumarol. The parasitemia was followed in 5 ducks in each of the 2 groups with malaria. Since some of the birds died on the 6th and 7th day the counts represent at this time an average from only 3 or 4 ducks. The average parasitemia is given as Exp. 2 in Fig. 1. The time at which these ducks died is shown in Table 1 as Exp. 2.

[1] Dicumarol is the collective trade-mark of the Wisconsin Alumni Research Foundation.

[2] Aided by a grant from the John and Mary R. Markle Foundation. The dicumarol was supplied by the Wm. S. Merrill Co.

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In both of the above experiments the parasitemia is much less in the group of ducks given dicumarol than it is in the group of untreated birds. The peak of parasitemia in the second experiment occurred approximately 24 hours later than it did in the non-treated group. This variation may be explained by the presence of fewer parasites during the second and third day of infection in the group given dicumarol.

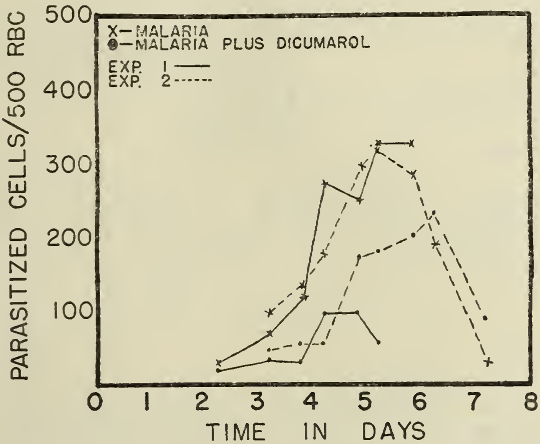

FIG. 1. The av erage degree of parasitemia of 5 ducks with *P. lophurae* infection and 5 ducks in fected with *P. lop hurae* and given dicumarol are shown in this figure. In Experiment 1 the ducks were given by mouth 50 mgs. of dicumarol immediately following inoculation and subsequently on the 1, 2, 4, and 5th day. The fifth day, 2 of the ducks given malaria and dicumarol were dead and in the afternoon 3 were dead. One duck with malaria was dead at this time.

In Exp. 2 the ducks were given 25 mgs. of dicumarol immediately following inoculation and subsequently on the 1, 2, 3, 4, and 5th day. On the afternoon of the 5th day 1 duck given malaria and dicumarol was dead. On the 6th day 1 with malaria and 2 given malaria and dicumarol were dead. On the 7th day 1 duck with malaria died and 2 with malaria and dicumarol.

It is of interest to observe that ducks given malaria and dicumarol die much earlier than birds given either malaria or dicumarol as shown in Table 1. In Exp. 1 as given in Table 1, 5 ducks with malaria and given dicumarol died from the group of 15 birds, before any of the ducks given either malaria or dicumarol died. In Exp. 2 as given in Table 1, 5 of the 10 ducks receiving both malaria and dicumarol died before any of the birds with either malaria or those given dicumarol died. In fact none of the 5 ducks given 25 mg. of dicumarol daily for 6 days died although 15 ducks from the group of 20 with malaria and given dicumarol succumb. The significant feature in these experiments is the time that death occurred in ducks with malaria when given dicumarol rather than the difference in the percentage of survivals when dicumarol was given.

To supplement the data on the lethal effect of dicumarol on malaria 30 ducks 14 days of age were used. Ten of these were given malaria, 15 were given malaria and

TABLE 1

Effect of Dicumarol on Malarial Infection in Ducks

NO. IN GROUP	AVG. WT. OF GROUP	GIVEN	NO. DIED	TIME IN DAYS—MG. DICUMAROL GIVEN—NO. OF DUCKS DEAD																						
				0	1	2	3	4				5						6				7
								8:30 a.m.	1 p.m.	2 p.m.	4 p.m.	8:30 a.m.	11 a.m.	1 p.m.	2 p.m.	4:30 p.m.	10:30 p.m.	8 a.m.	8:30 a.m.	11 a.m.	2 p.m.	1 p.m.
								Experiment I														
10	Gm. 414	Malaria	7											1		2		4				
15	442	Malaria Dicumarol	7	*50**	*50*	*50* 2		*50*				*50* 2	1			2						
15	436	Dicumarol	2	*50*	*50*	*50*												2				
								Experiment II														
20	430	Malaria	15															7		4	4	
10	477	Malaria Dicumarol	8	*25*	*25*	*25* 1	*25* 1	*25*	1			*25* 1		1				2				1
5	429	Dicumarol	0	*25*	*25*	*25*	*25*	*25*				*25*										
								Experiment III														
10		Malaria	7													2	4		1			
15	393	Malaria Dicumarol	15	*50*	*50*	*50*	*100*	*100*		1	5	*100* 1			6	1	1	*100*				
5	393	Dicumarol	3	*50*	*50*	*50*	*100*	*100* 1				*100*	1					*100* 1				

* Mg. of dicumarol given by mouth.

dicumarol and 5 were given only dicumarol. Thirteen of the group of 15 ducks with malaria and given dicumarol were dead and 2 of the 5 ducks given only dicumarol were dead before any of the ducks with malaria died. The time of death and the amount of dicumarol given to this group of ducks are shown in Table 1 as Exp. 3.

Effect of Dicumarol on the Erythrocyte Count in Normal Ducks

There occurs a sharp drop in the total number of red cells in the peripheral blood 2 to 4 hours following the oral administration of large doses of dicumarol. This effect on the red blood cell count is shown in Fig. 2 in 2 ducks from a group of 12 in which the counts were followed. A greater decrease occurred in the number of red cells usually following the first dose of dicumarol than upon subsequent doses of equal size. The plasma from these dicumarol treated ducks was the same color as that from normal birds. The average red blood cell count on three ducks given dicumarol was 1.85 M. and the average hematocrit reading was 2.96 while the control was 2.55 M. with a hematocrit reading of 3.4.

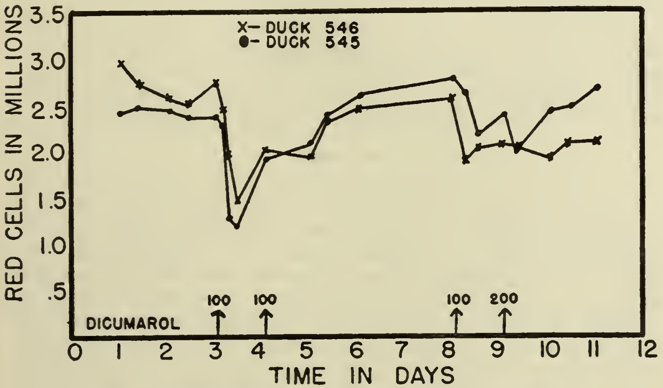

FIG. 2. THE ERYTHROCYTE COUNT IN 2 DUCKS GIVEN DICUMAROL

Observations on the Acid-Base Balance in Ducks Given Dicumarol. The rapidity in which death occurred in many of the ducks given larger amounts of dicumarol and the failure to observe any pathological changes in these birds suggested that death probably was resulting from a disturbance in their acid-base relationship. A group of 11 ducks were given single and multiple large doses of dicumarol and sacrificed at varying intervals thereafter. A total erythrocyte count was made at the time of death. The birds were killed by clamping their necks. Blood was obtained from the heart and placed under paraffin oil. Heparin in a dilution of 1 to 9 was used as the anticoagulant. The carbon dioxide content and the carbon dioxide combining power was determined on the plasma according to the methods given by Peters and van Slyke (1932) for the volumetric blood gas apparatus. The results are as follows:

RBC COUNT	CO_2 CONTENT	CO_2 COMBINING POWER
2.0	36	28.1
1.23	38.9	31.9
1.06	32.2	26.2
1.65	44.4	40.9
1.49	44.4	53.9
1.24	47.0	48.5
1.30	47.0	40.0
1.78	50.8	39.0
1.99	45.2	39.0
1.89	47.1	40.9
Control: 2.55 (40)	46.9 (21)	51.4 (12)

The control values are indicated above and the number of birds used to establish them is shown within the bracket. These data show that an anemia develops following the oral administration of dicumarol and this is accompanied by an acidosis. The carbon dioxide content of the plasma usually remains approximately normal, however, it is decreased in some of the birds which show a severe acidosis.

DISCUSSION

The parasitemia is less in ducks infected with *P. lophurae* and given multiple doses of dicumarol than it is in non-treated birds. There is nothing in these experiments to indicate the mechanism by which this effect is produced. It does not appear likely that the decrease in the parasitemia results from the anemia since the latter does not become too severe. Furthermore, the degree of parasitemia is based upon the number of parasitized cells per 500 red blood cells and not upon the total number of red cells within the circulation. Dicumarol is not a satisfactory parasitical agent since ducks infected with *P. lophurae* are more likely to die sooner when given dicumarol than either untreated birds or normal birds given only the dicumarol as shown in Exp. 2 in Table 1. The time at which death occurs in many of these ducks with malaria and treated with dicumarol is too soon for the parasitemia to play a significant rôle. The degree of anemia resulting from the parasitemia also is insignificant at this time.

The anemia that follows the giving of dicumarol apparently is not the lethal factor since there is only approximately a 50 per cent decrease in the number of red blood cells at the time of death. This decrease in the number of red blood cells seems to be the result of plasma dilution as indicated by a corresponding decrease in cell volume. Furthermore, the plasma does not show any hemoglobin to suggest that the anemia might be the result of lysis. The carbon dioxide content of the plasma is approximately the same as that in normal birds. There is, however, a decrease in the carbon dioxide combining power of plasma in dicumarol treated ducks. It is probable that the earlier death in the dicumarol-malarial infected birds results from the combination of the acidosis produced by the dicumarol and the acidosis which accompanies the malarial infection (Rigdon and McCain unpub.).

Wakin and associates (1943) were able to produce death of dogs within a few hours following the intravenous injection of large amounts of dicumarol. Their animals

did not show any change in either the prothrombin or the coagulation time. Richards and Cortell (1942) have reported a decrease in both the number of red cells and the hemoglobin in dogs given dicumarol. Vitamin K does not inhibit the apparent decrease in the number of red cells following the oral administration of dicumarol in ducks.

Dicumarol when given to normal ducks in large daily doses for several days produces bleeding into the subcutaneous tissues. Large amounts of blood may escape when a feather is plucked. Larger doses of the drug may produce death within an interval of 4 to 6 hours. Recently it has been observed that ducks fed a low Vitamin A ration are more likely to die when given large doses of dicumarol than birds fed either a standard ration or a low Vitamin A ration supplemented with Vitamin A. The mechanism of this protective action of Vitamin A against the acute lethal action of dicumarol has not been explained (Rigdon and Varnedoe unpub.).

SUMMARY

Ducks infected with *P. lophurae* and given multiple doses of dicumarol by mouth have a lower degree of parasitemia than non-treated malarial infected birds. The combination of dicumarol and malaria produces an earlier death than either dicumarol and malaria alone. The mechanism of this high lethal effect is not known.

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EXPERIENCE WITH USE OF PERMANENT WORKS FOR THE CONTROL OF ANOPHELINES ON IMPOUNDED WATER

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The malaria control program for the Kentucky Reservoir of the Tennessee Valley Authority was described in a report presented to the National Malaria Society by Bishop and Gartrell (1944) at the 1943 meeting. The program provided for the use of permanent malaria control approaches in parts of the reservoir where the conventional antilarval measures could not be relied upon for adequate mosquito control. The permanent approaches provided for the large scale use of diking and dewatering, filling and deepening to eliminate shallow marginal mosquito-breeding areas and land use restriction in one large area where the above measures were not particularly applicable. Malaria control features were integrated with other reservoir plans and major economies were effected. For example, the total cost of all of the dewatering projects was offset by savings on highway and railroad fill protection and on clearing located within the dikes.

The locations of areas where diking and dewatering, filling and deepening and land use restriction were applied are shown on Figure 1 and shoreline analysis data are summarized in Table 1. Major construction was completed prior to filling the lake to normal pool elevation 359 feet in the spring of 1945. It is the purpose of this report to review experiences during the 1945 and 1946 malaria control seasons and to provide information that may be helpful to malaria control workers in the use of these measures elsewhere.

DIKING AND DEWATERING

Initially twenty-two areas were investigated to determine the feasibility of utilizing diking and dewatering for anopheline mosquito control of which eight were approved and constructed. Data on these eight projects are summarized in Table 2. The concrete pumping plants range in size from 16,000 g.p.m. up to 250,000 g.p.m. with a combined capacity for the eight projects of 672,000 g.p.m. Two of the stations are electric motor-driven and the other six are gasoline engine-driven. All levees are of earth construction with bermuda sod protection on the inside slopes, top and outside down to elevation 359 feet or normal pool elevation. Spillways or overflow sections were provided by grading sections of natural ground to a crest elevation approximately one foot above normal pool elevation (more where backwater effect on a tributary stream was taken into account) with flat horizontal slopes (0.2 per cent to 0.14 per cent). A schematic drawing of a typical gasoline engine-driven pumping station is given in Figure 2, and a general layout and section of one of the dewatering projects is given in Figure 3.

Although numberous operating difficulties have been encountered and deficiencies in the original plans have developed, experience during the first two years of operation has proven that diking and dewatering can be utilized effectively and economically for malaria mosquito control in certain types of situations encountered on impounded water projects. Since the projects were put in operation many additions, changes and modifications are being made to improve the operation of the pumping stations

TABLE 1

Summary of malaria control shoreline analysis data Kentucky reservoir

MALARIA CONTROL MEASURE	TOTAL LENGTH OF SHORELINE			ACRES OF MOSQUITO BREEDING AREA 359 FT.–356 FT.		
	Miles	Per cent of Total Miles	Per cent of Treatment Miles	Acres	Per cent of Total Acres	Per cent of Treatment Acres
Diking and Dewatering	251	11	21	4,115	23	33
Filling and Deepening	106	5	9	1,625	9	13
Land Use Restriction	260	12	22	2,123	12	17
Larvicidal Control	581	27	48	4,600	26	37
No Work Required	987	45		5,497	30	
Total	2,185	100	100	17,960	100	100

TABLE 2

Summary of data—Malaria control dewatering projects—Kentucky reservoir

PROJECT	MALARIA CONTROL DATA			Construction Data									
				Levee		Drainage		Diversion Ditch		Spillway	Pumping Plant		Days to draw-down from 359 ft.
	Miles Shore-line	Acres 359 ft.–356 ft.	Popu-lation 1-Mi. Zone	Length Ft.	Cu. Yds.	Length Ft.	Cu. Yds.	Length Ft.	Cu. Yds.	Const. Cu. Yds.	No. Pumps	Cap. g.p.m.	
West Sandy	59	737	1,155	3,600	284,125	170,200	156,800			313,520	6	250,000	18
Big Sandy	30	358	1,130	21,000	108,260	48,300	100,650	19,985	228,660	59,780	2	30,000	14
Camden	32	795	560	34,200	490,340	*69,900	*103,240				3	145,000	22
Duck River	60	1,700	940	46,500	457,700	116,200	*249,470				4	171,000	24
Busseltown	15	80	190	600	10,965	12,900	34,540			2,290	2	18,000	12
East Perryville	16	114	490	2,600	31,730	32,250	91,440				2	16,000	12
Perryville	21	142	435	3,200	49,370	18,100	56,740			13,120	2	24,000	14
Gumdale	18	133	240	2,600	25,840	34,050	81,590	2,600	31,160	130	2	18,000	12
Total	251	4,059	5,140	114,300	1,458,330	501,900	874,470	22,585	259,823	388,540	23	672,000	

* Does not include borrow pit ditches.

and pumping schedules, to perfect interior drainage, to reduce seepage inflow, and to improve spillways and levee protection.

Best results have been obtained where the pumping station was designed to pump down 2 or 3 feet below the lowest part of the area to be dewatered, with a low area or sump at the station of sufficient capacity to retain several days inflow during dry periods. On two of the projects, Camden and West Sandy, experience has indicated

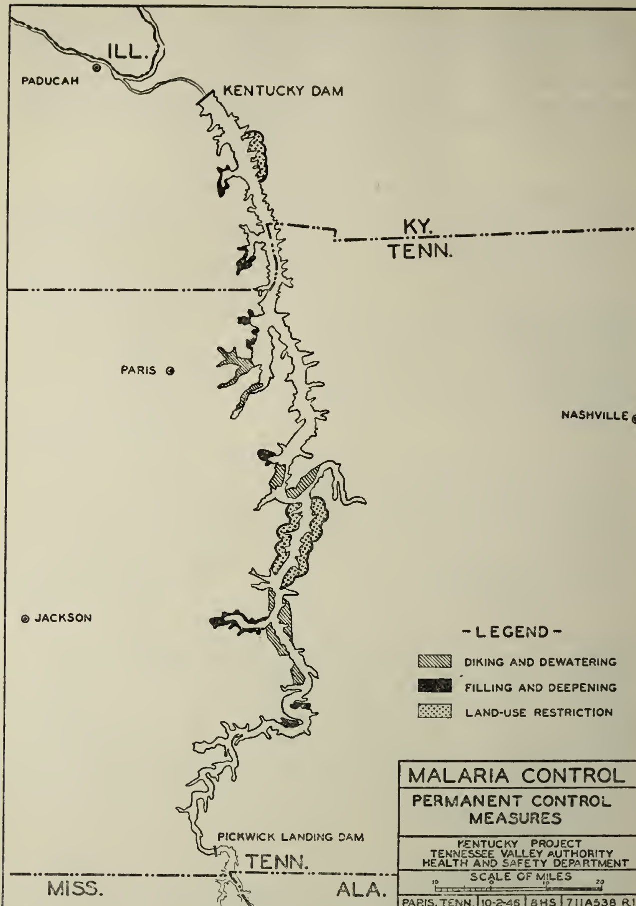


Fig. 1. Map showing location of areas of operation

that lower pumpdown than is now possible will be required to give adequate mosquito control in the lower parts of the dike areas, and studies are now in progress to deter-

mine the most feasible method for providing the additional drawdown; that is, lowering present pumps or installing additional pumps. In general, it is important that the main interior drainage ditch of diking projects be of sufficient depth and slope to carry normal runoff to the pumping station at a rate approximately the same as the capacity of the low level pump. Special care should be taken in designing drainage structures for interior ditches to assure unrestricted flow to the pumping station. In one of the dewatering projects (Camden) the culvert under the highway and railroad fills, which traverse the dewatered area, has proven to be a "bottleneck"

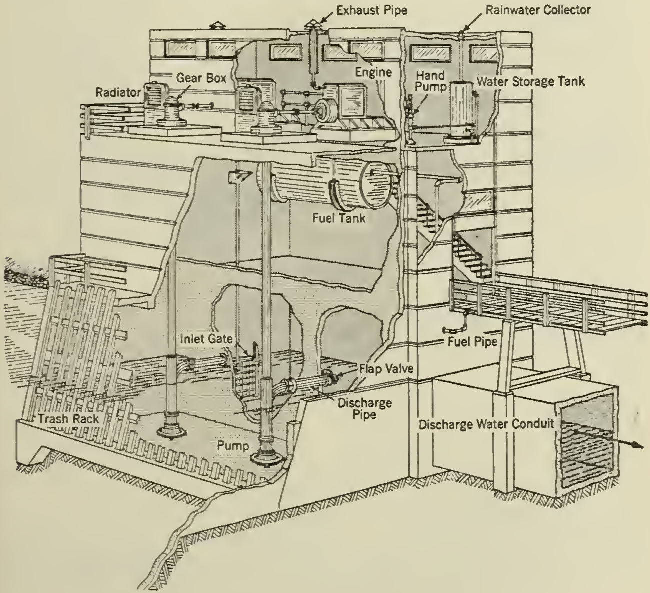
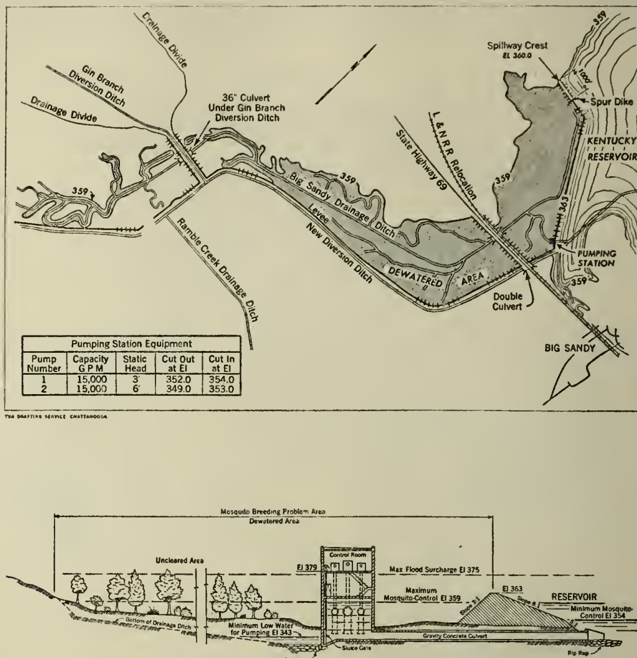


FIG. 2. Schematic design of a typical pumping station, Kentucky Reservoir.

in getting water from the south half of the area to the pumping station and water in this portion is nearly always one-half to one foot higher than at the pumping station. The low level pump at this station has a capacity of 45,000 g.p.m., which pumps the northern portion of the area down to cut-off elevation faster than the connecting culvert will lower the southern half of the area. A somewhat smaller pump operating continuously would be desirable.

All of the pumping stations were designed and equipped with automatic operating devices, including float switches for starting and stopping the pumps and protective

devices for stopping the pumps when abnormal conditions arise. However, normal operating schedules provide for starting the pumps, manually, since it is necessary to check lubrication on pumps at least once a day when operating, and with the exception of two stations, Duck River and West Sandy, the stations are allowed to operate unattended and cut-off at predetermined elevations. The West Sandy sta-



Pumping Station Equipment				
Pump Number	Capacity G P M	Static Head	Cut Out at El	Cut In at El
1	15,000	3'	352.0	354.0
2	15,000	6'	349.0	353.0

FIG. 3. General lay out and typical section of malaria control dewatering project—Big Sandy River area of Kentucky Reservoir.

tion, with six electric-driven pumps having a combined capacity of 250,000 g.p.m., is attended at all times when pumping due to the fact that protective fuze blocks have not yet been installed in the running circuits. When the station was first put in service in 1945, one of the 100 h.p. motors burned out due to failure of a circuit breaker. A period of two months was required to repair the motor. During the period this pump was out of service, the lower end of the dike area was flooded and

heavy mosquito production necessitated larvicidal treatment with DDT aerosol applied by plane. This experience indicates that on projects where large inflow is expected from occasional rains that reserve pump capacity for low level operation should be provided. The Duck River pumping station, which has four gasoline engine-driven pumps with a combined capacity of 171,000 g.p.m., is also attended while operating. On two occasions fires have occurred at this station when the motors cut off on automatic operation due to the fact that the ignition cuts off under full throttle and frequently backfires. Only the alertness of the operator on duty in suppressing the fires prevented serious damage. Automatic CO_2 fire extinguisher systems are being installed at all gasoline-driven pumping stations and it is anticipated that the Duck River station in the future will be operated unattended also, except during periods of heavy pumping.

The following additions to the pumping stations, as originally constructed, are being made to improve operating efficiency: Screening of engine rooms and outside motors to prevent entry of dirt daubing insects, installation of dashpots to reduce slamming of flap gates when closing under high head, installation of walkways or floor openings as required for inspection and servicing of flap gates and replacing oil lines to pump bearings with flexible tubing to prevent breakage from vibration.

In planning the system of levees, spillways and interior drainage for a malaria control dewatering project a number of factors should be taken into account. First of all, there should be an economic balancing as to levee location with a view to enclosing a maximum of mosquito problem areas. In the main stream reservoirs of the Tennessee River Development experience has shown that, with proper water level management, the anopheline mosquito areas can be limited principally to the flat shallows in a 2–3 foot zone below the normal water elevation. Inclusion of deeper portions of areas therefore is unnecessary for malaria control purposes except that the topography of the area occasionally may be such that economical levee and drainage systems would not be feasible without enclosing some sizeable low areas. Increased pumping costs, due to increased volume of the area to be dewatered and also increased seepage inflow because of greater head differential, result from enclosing deeper areas than are required for malaria control. This has been strikingly illustrated by the Duck River project, which included a sizeable low area where several hundred acres of timber would have had to be cleared. Including this low area increased the operating head of the pumps during the greater part of the pumping season. Of still more importance is the fact that large marshy areas have developed from seepage inflow into these low areas which are requiring airplane larvicidal operations for mosquito control during the latter part of the season.

After preliminary levee locations have been decided upon, geological investigations should be made to evaluate potentialities of excessive seepage inflow into the area after impoundage. In general, however, with the low heads that would normally exist on malaria control dikes, seepage inflow should not offer a serious problem, unless there existed the possibility of underground channelling occurring through rock fissures with resultant free flow of lake water into the diked area. A major seepage problem developed in only one of the dewatering projects. When this area was first dewatered in the spring of 1945, it was found that a total inflow of 119 c.f.s.

was coming from the lake, approximately 55 c.f.s. originated from seepage areas over a large portion of the extreme upper end of the project with 35 c.f.s. originating in two sections of a borrow ditch located inside a section of the main levee. This inflow overtaxed the capacity of the pumping plant, which had to operate almost continuously until fall when the main lake level was lowered and the seepage areas inside the dikes were blocked off. The seepage area in upper part of the project was cleared and rebrushed and a water control structure installed for purpose of operation as an independent impoundage. The ditch where the leaks occurred was blocked at each end and an earth spillway constructed at the lower one to permit partial drainage of the area served by the ditch. These measures were effective in reducing seepage and surveys are now in progress to determine additional drainage requirements for malaria mosquito control. Two small lateral impoundages in seepage areas have been constructed, one in the Perryville Project and one in the Gumdale Project to reduce pumping and to permit independent water level management for mosquito control. The experience with inflow in the levee borrow pit ditch in the Duck River project and a similar experience in the Perryville Project where the main drainage ditch cut through a high ridge serves to caution against construction of ditches near the levees and using drainage layouts requiring deep cuts through ridges underlaid with sand and gravel strata. In the Perryville situation it was not practical to block off the ditch and the sandboils made it impossible to maintain the desired grade, so a corrugated pipe with weep holes was put into grade, and backfilled with gravel and sand. This pipe functioned satisfactorily and an additional pipe is to be installed to more completely dewater the area above the pipe installation and to permit more desirable pumping schedules.

The malaria control dikes are subject to complete submergence during flood control operations of the reservoir, which may require filling the lake as high as elevation 375 feet, sixteen feet above normal pool elevation 359 feet. Overflow sections or spillways are provided to prevent spilling over the levees by filling the areas as the reservoir level rises a foot or more above normal pool elevation. However, on two of the projects, Duck River and Big Sandy River, inflow into the diked areas occurs as a result of headwater from floods on tributary streams. The lower Big Sandy spillway has proven adequate to pass headwater floods without serious spillage over the levee. Likewise, the West Sandy spillway has proven adequate to handle headwater floods. During the winters of 1944–45 and 1945–46, floods on Duck River topped the upper levees of the dewatering project and inflow exceeded the capacity of the lower spillways, causing spillage over and consequent damage to the lower main levee. Most of the damage occurred where the levee had been used as a road, which had created ruts and damaged the bermuda sod. All levees are now barricaded and their use as roads is limited to that required for inspection and maintenance.

The hydrograph and operating data for the 1946 mosquito control season for one of the dewatering projects, Big Sandy River, is given in Figure 4 and illustrates the operation of a typical malaria control project where most of the runoff is diverted and there is little or no seepage. In the Camden and West Sandy Projects growing

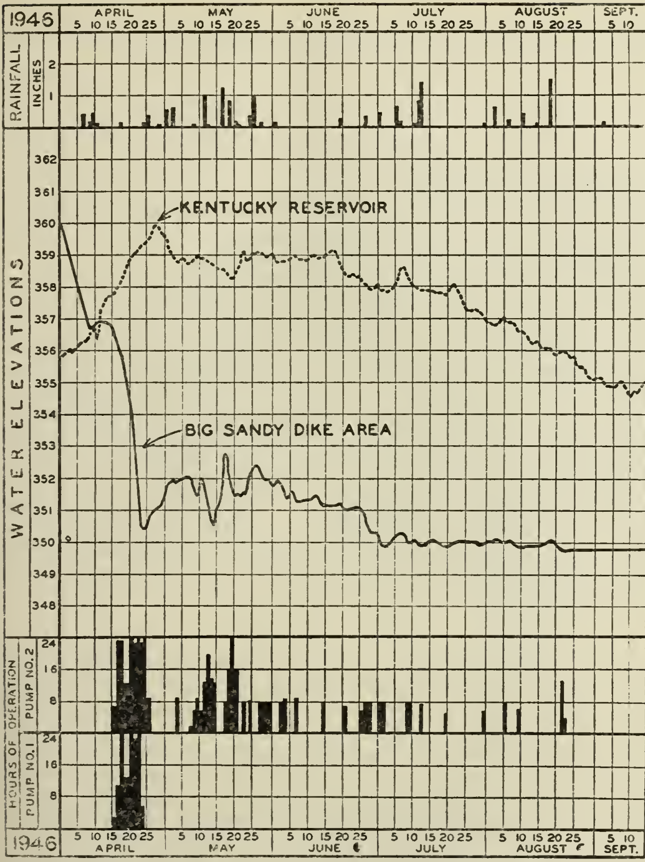


FIG. 4. Hydrograph and operating data, malaria control dewatering project, Big Sandy River, Kentucky Reservoir.

timber inside the dikes is required for protection of highway and railroad fills. These areas are dewatered in the spring as soon as probability of flood control operations of the reservoir has passed and are kept pumped down as late in the fall and winter

as is practical, usually until January and February floods occur. On the other six projects pumpdown begins when production of *A. quadrimaculatus* occurs and pumping is discontinued at the end of the mosquito control season.

Pumping schedules for all projects for the 1947 season, except Camden and West Sandy, provide for prolonging the time required for initial pumpdown by following a predetermined rate of recession, or "rule curve" of maximum elevations. Under this method of operation, the areas would not be dewatered to minimum elevation until July 15 or later. This type of schedule is expected to reduce pumping by reducing seepage and the static head on the pumps during a major portion of the pumping season and retard vegetative growth inside the dike, particularly in the lower portions of the areas where marshy conditions frequently prevail and anopheline mosquito production occurs during the latter part of the season.

From the above discussions, it is apparent that numerous operating difficulties have been encountered in the use of large scale dewatering projects for malaria control on impounded water and that adjustments, additions and changes in original plans are being made in order that all of the projects will be more effective for malaria control. Prospects are favorable that, with continued progressive improvement, this objective will be achieved in the near future. In evaluating the worth of this measure for malaria control purposes, consideration must be given to the fact that it was applied only in areas where other permanent control measures, filling and deepening or land use restriction were not feasible or considerably more costly and where conditions were such that the usual antilarval program of shoreline maintenance and larviciding would have been not only costly to apply but would have been relatively ineffective. Secondary benefits that have been realized from the malaria control dewatering projects include retention of large tracts of land in productive agricultural use and creation of ideal waterfowl feeding grounds when the areas are flooded during the winter months.

FILLING AND DEEPENING

For malaria control purposes, the elimination of mosquito breeding areas by filling deepening or a combination of filling and deepening is ideal, since the problem areas are permanently built out of the reservoir and there is practically no maintenance cost. The total amount of material to be handled can be held to a minimum by by maximum utilization of the combination filling and deepening procedures. Theoretically, only 25 per cent as much material has to be handled where deepening and filling is utilized as would be required for complete filling or deepening alone. A plan and section of a typical filling and deepening project are shown in Figure 5 and data for all of the projects are given in Table 3. The areas selected for this type of treatment included major mosquito problem areas adjacent to relatively thickly populated sections near the reservoir except those where economy indicated the use of diking and dewatering. The eight projects constructed required work in 81 areas, totaling 1,506,700 cubic yards of net fill, and eliminated 52 miles of shoreline and 1,625 acres of problem flats. The upper three foot zone, 359 feet–356 feet, was used as a basis for planning deepening and filling projects. Construction of most of the projects was carried out in the summer and fall of 1944, prior to impoundage, however, a

portion of the work on the Beech River and Cypress Creek projects was done in the fall of 1945 and spring of 1946 after impoundage.

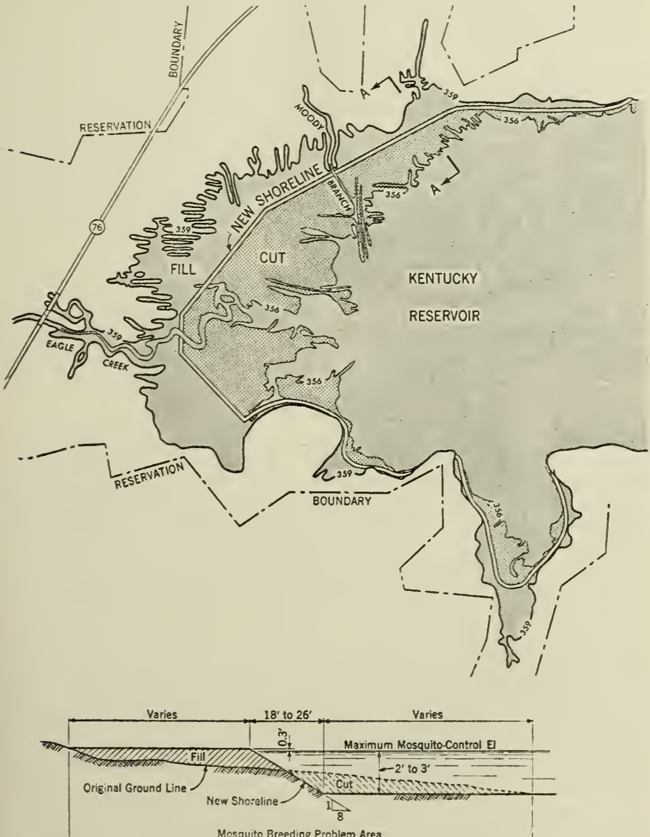


FIG. 5. Plan and section of a typical filling and deepening project, Eagle Creek, Kentucky Reservoir.

Preliminary plans and estimates of quantities for the deepening and filling projects were prepared from topography sheets with one foot contours mapped to a scale of

1 inch = 500 feet. An approximate shoreline location was staked in the field and the final shoreline was established during construction according to actual balancing of excavation and fill areas by working from the lower edge of the cut areas and the upper part of the fill areas. As the cut and fill sections approached each other, material was shifted along the face of the fill to establish a regular shoreline with uniform slope. Flat grades of 359.2 feet and 356.0 feet were used in the fill and cut areas, respectively. The 0.2 feet above normal pool elevation was added to the fills to allow for construction tolerance and settlement and from experience it is believed this should be increased on future work to 0.3 feet. In marshy areas where complete filling had to be used or excavation in the cut areas required use of draglines, field adjustments were made to permit leaving portions of the areas below elevation 357 feet unworked. Experience has demonstrated that these adjustments have not materially diminished the effectiveness of the projects under normal water level management schedules. Pan scrapers and bulldozers were used for handling most of the material and road patrols were used for final leveling of the fill sections. Draglines were used for the construction of drainage channel changes and major drainage ditches. During the first season of impoundage, shallow V-type ditches were constructed by hand to drain minor depressions in the fill areas. No major difficulties developed during construction except on one project (Cypress Creek) where boggy ground conditions limited the use of bulldozers and pan scrapers for effecting a balanced cut and fill section. A drag scraper is being developed for excavating the cut section under boggy conditions on future work in other reservoirs. In the areas where deepening and filling has been done, only limited mosquito production has occurred except during short periods of time when the lake has been above normal pool elevation during the mosquito breeding season. Practically no larvicides have been required in these areas and growth removal has been limited to that required for drainage maintenance. Average mosquito station counts in these areas have

TABLE 3

Summary of data—Malaria control shoreline filling and deepening projects—Kentucky reservoir

PROJECT	POPULATION 1-MI. ZONE	NO. AREAS WORKED	MILES SHORELINE		ACRES 359 FT. – 356 FT.	CU. YDS.* FILL REQUIRED	CU. YDS. FILL/ACRE OF MOSQ. BREEDING AREA ELIMINATED 359 FT.–356 FT.	REMARKS
			359 ft. Contour	Eliminated				
Jonathan Creek	610	13	13.6	7.6	258.4	205,500	795	Cut and Fill
Blood River	535	6	16.2	10.8	432.0	361,200	836	Cut and Fill
Eagle Creek	355	6	11.7	7.2	155.1	133,500	986	Cut and Fill
Swamp Creek	285	11	10.4	3.8	223.9	94,900	424	Cut and Fill
Cypress Creek	340	3	4.3	1.8	140.0	229,100	1,636	Fill from borrow
Beech River	1,030	29	36.0	18.5	321.0	331,100	1,031	Cut and fill
Hardins Landing	130	8	6.2	1.2	45.9	94,300	2,054	Fill from borrow
Clifton Bend	1,205	5	7.2	1.1	48.5	57,100	1,177	Fill from borrow
Total	4,490	81	105.6	52.0	1,624.8	1,506,700	927	

* Net fill in embankment as measured by before and after cross sections. Measured excavation exceeded these quantities by percentages varying from 28 per cent to 55 per cent depending upon natural ground conditions in the fill areas.

been the lowest of any similar group of stations in the reservoir. The top of the fill areas are being used for grazing and hay production.

In view of the unusual success of this type of permanent mosquito control, similar work is being done in other parts of the reservoir to eliminate smaller problem areas which could not have been predicted with certainty before impoundage. This permanent shoreline improvement of the smaller areas is being applied as part of the malaria control maintenance program. Only a portion of the total work needed of this type can be done each year due to a relatively short working period in the late summer and fall when weather and lake elevations are favorable and the economic limitations of not over-investing in heavy earth-moving equipment. At the present time it is difficult or impossible to contract this type of work. However, by planning the work on a long range basis, working areas in priority order based on need and relation to other permanent works, it will be only a matter of a few years until large blocks of the reservoir shoreline will be improved to the extent that all annual mosquito control operations, except possibly aquatic growth control, can be discontinued. In the interim, mosquito control operations are contemplated consisting principally of growth control and airplane larviciding.

The types of operations carried out on the maintenance shoreline improvement program are illustrated in Figure 6. In addition to bulldozers shown in the illustration, pan scrapers and draglines are also used on this work.

LAND USE RESTRICTION

In one twenty-mile long section of the middle reservoir area land use restriction to daytime occupancy was applied as the most practical permanent approach to malaria control under the existing conditions. Diking and dewatering or deepening and filling was not applicable due to the disconnected nature of the marginal mosquito breeding area. Land use restriction was indicated since relatively few families lived in the one-mile zone from the reservoir. Two plans for effecting removal of families from the zone were considered, namely, (1) outright purchase of the land and (2) purchasing malaria control easements providing for removal of all human habitation. The latter plan was employed since it left the land in private ownership and permitted all normal uses except human habitation. This plan involved the purchase of easements on 20,073 acres of land and the removal of 133 families. This measure permitted the elimination of all mosquito control maintenance after impoundage. The plan was very carefully put into operation with the cooperation of the State and County Health Departments and other local agencies. The purpose of the measure was fully explained to affected residents by means of community meetings. There was no substantial opposition and the acquisition of easements was made along with the usual acquisition of lands in the reservoir proper. This approach has proven quite satisfactory and there has been no substantial change in the land use by the individual owners. The only practical difference is that the land owners or lessees live outside the one-mile limit from the reservoir.

Land use restriction is a positive approach to malaria control about impoundages but would have only limited application for various reasons. The combination of conditions governing its use would be a sparse population living in the one-mile zone

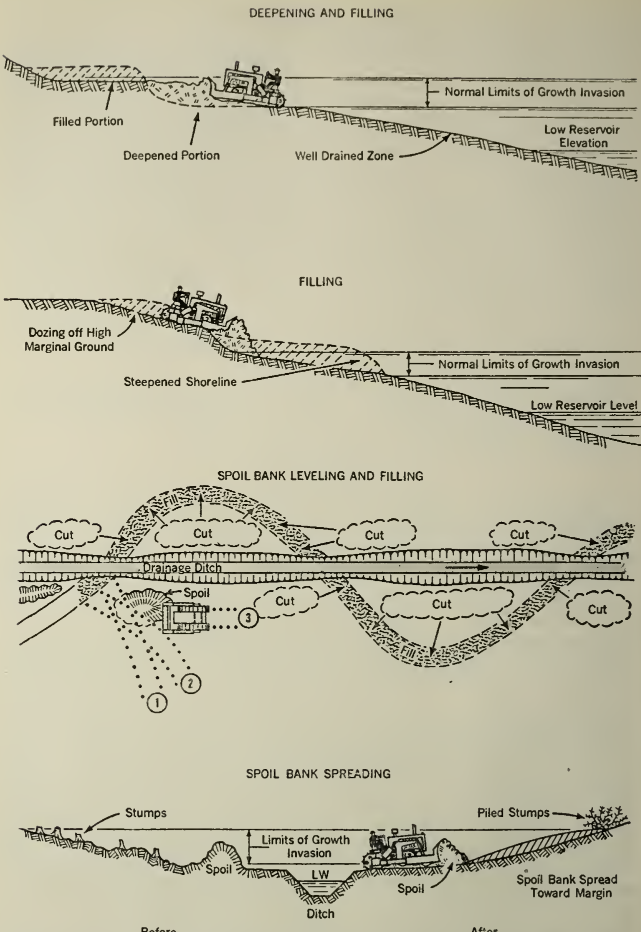


FIG. 6. Typical operations for permanent shoreline improvement carried out as part of malaria control maintenance project, Kentucky Reservoir.

of the reservoir where mosquito control would be difficult and expensive. It would not be used where any considerable potential for night-time occupancy might develop as for recreation. Obviously this approach could not be efficiently applied unless supported by a considerable majority of the families affected. In another section of the reservoir land use restriction was applied in conjunction with the development of a woodland wildlife refuge which has permitted the elimination of mosquito control maintenance operations in portions of the reservoir within flight range.

SUMMARY

There is presented a review of the Tennessee Valley Authority's initial experiences during the seasons of 1945 and 1946 with the use of permanent malaria control measures in the Kentucky Reservoir.

The measures applied in this reservoir consisted of diking and dewatering and deepening and filling to eliminate mosquito-breeding areas and land use restriction to remove population from the one-mile zone. The construction work associated with the application of these measures was undertaken along with other preimpoundage reservoir preparation activities.

Eight diking and dewatering projects were constructed. On the basis of two years experience with the operation of these projects, it is concluded that diking and dewatering can be utilized effectively and economically for malaria mosquito control in certain types of situations encountered on impounded water projects. A detail account is given of the problems which have been encountered in the operation and maintenance of these projects and corrective measures which are being applied.

The use of deepening and filling to eliminate mosquito breeding areas was used on nine major projects embracing eighty-one sections of shoreline. A total of 1,625 acres mosquito breeding areas was eliminated which required 1,506,700 cubic yards of net fill. This measure has required practically no maintenance and satisfactory mosquito control has been obtained. On the basis of this experience, the measure is being expanded as a part of the maintenance program to embrace other similar areas not included in the original program.

An account is given of the application of land use restriction to daytime occupancy in the one-mile zone in one twenty-mile long section of the middle reservoir where an unusual combination of conditions was encountered. This measure required the purchase of malaria control easements on 20,073 acres in the one-mile zone and removal of 133 families. The measure was applied without difficulty and all normal uses of land except habitation has continued.

RESUMEN

Este es un análisis de las experiencias iniciales de TUA durante 1945 y 1946 con el empleo de medidas permanentes de control antimalárico en el embalse Kentucky.

Consistieron las medidas tomadas en éste embalse en canalizaciones y desagües, excavación y rellenos para eliminar los criaderos de mosquitos y restricción en el uso de la tierra para trasladar a la población fuera de la zona de una milla. El trabajo

de construcción unido a la aplicación de estas medidas se acometió al tiempo con otras actividades preparatorias al embalse.

Ocho proyectos de canalización y desagüe fueron construídos. Con la experiencia de dos años de trabajo en estos proyectos, se concluyó que la canalización y desagües pueden ser utilizados efectiva y económicamente en el control antimalárico en ciertas situaciones encontradas en embalses.

Hace un recuento detallado de los problemas encontrados en la operación y conservación de estas obras y de las medidas correctivas empleadas.

Se hizo uso de excavación y relleno para la eliminación de criaderos de mosquitos en nueve obras de importancia comprendienco ochenta y una secciones de la orilla. Se eliminó un total de 1625 acres de criaderos de mosquitos utilizando 1506700 yardas cúbicas netas de relleno. Este sistema no requiere practicamente conservación alguna y se ha obtenido un control satisfactorio del mosquito. Basados en ésta experiencia, se ha extendido el uso del sistema como parte del programa de conservación incluyendo otras áreas similares no contempladas en el programa original.

De cuenta de la aplicación de la restricción de uso de la tierra y la ocupación solo durante el día en la zona de una milla a lo largo de una sección de veinte millas del embalse central donde se encontró una combinación especial de factores. Esta medida hizo necesaria la compra de mejoras pera control antimalárico en 20073 acres dentro de la zona de una milla y el traslado de 133 familias.

Esta medida se aplicó sin dificultad alguna y han continuado todos los usos normales de la tierra, excepto para habitación.

Acknowledgement: Illustrations for Figures 2, 3, 5, and 6 were prepared originally for manual on "Malaria Control on Impounded Water" (In Press).

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THE RELATIONSHIP BETWEEN INFECTIVENESS AND DENSITIES OF *ANOPHELES QUADRIMACULATUS* IN A MALARIOUS AREA IN SOUTH CAROLINA

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The density of the *Anopheles* vector is considered a major factor in the transmission of malaria. There are, for the U. S., few studies associating *Anopheles* abundance with infective mosquitoes. Williams (1943) finds it impossible "to set any figure for the density of *An. quadrimaculatus* above which there is a hazard from malaria and below which there is none." Recently, in the M. C. W. A. program of the U. S. Public Health Service, the criterion for considering an area "out of satisfactory control" has been a count for three successive weeks exceeding 10 female *quadrimaculatus* in any station within a quarter of a mile of the protected area. The desirability of determining more nearly the level of vector density necessary to support transmission has prompted us to present the following dissection and inspection data, from a study area in Clarendon County, S. C., located on the north shore of the Santee Reservoir, about 4 miles west of the Santee Dam. It is approximately four miles in length by four miles in width, and traversed from north to south by Potato Creek. The houses in one half of this area were sprayed twice with 2.5 per cent DDT in 1945, and in the entire area twice in 1946.

TABLE 1

Infection Rates of Malaria in Humans

MONTH	PER CENT POS.	MONTH	PER CENT POS.
Aug. 1943	38.3	Oct. 1945	7.4
Oct. 1944	38.4	Nov.	9.6
Nov.	27.3	Dec.	6.3
Dec.	17.6	Jan. 1946	6.4
Jan. 1945	12.0	Feb.	3.8
Feb.	7.9	March	1.8
March	12.2	April	—
April	13.6	May	1.2
May	10.6	June	2.9
June	9.3	July	0.7
July	5.8	Aug.	1.0
Aug.	4.7	Sept.	0
Sept.	9.3	Oct.	0

Relative to the premises under weekly inspection (50 in 1945 and 127 in 1946), it has been determined that the mule stables afford the most reliable indices expressing density. Mosquitoes for dissection were obtained from such stations within a mile

of the reservoir where human infection rates are highest. Malaria prevalence in this area, as measured by thick-blood film surveys, is shown in Table 1.

Eighteen thousand eight-hundred and twenty-six dissections from June to November, inclusive, in 1945 yielded 33 gland positive mosquitoes for an overall rate of 0.17

TABLE 2

Infective Rates of An. quadrimaculatus, *1945 and 1946*

1945				1946			
Month	Total dissected	Total infective*	Rate	Month	Total dissected	Total infective*	Rate
			per cent				*per cent*
June	2,016	0	0	May	3,570	2	0.06
July	3,804	5	0.13	June	2,678	3	.11
August	5,098	7	.14	July	4,197	2	.05
September	4,424	7	.16	August	3,511	4	.11
October	3,389	10	.29	September 1–10	811	0	0
November	95	4	4.21				
Totals.............	18,826	33	0.17	Totals...........	14,767	11	0.07

* Salivary gland positive only.

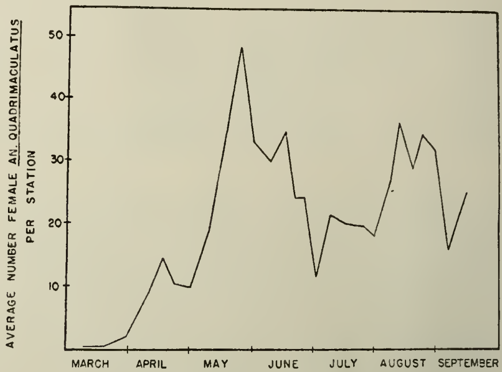

FIG. 1. Average *A. Quadrimaculatus* Densities — 1946

per cent. In 1946, 14,767 dissections from May to September 10 inclusive, yielded 11 gland positive specimens for a rate of 0.07 per cent. These rates are not intended for comparison but as being supplementary, one to the other. The later part of the probable season of transmission was covered in 1945, and the earlier part in 1946.

TABLE 3

Station Counts of An. quadrimaculatus *for Week During which Infective Mosquito was Collected, and Four Preceding Weeks, 1945 and 1946*

PRECEDING WEEKS					WEEK OF POSITIVE
Average	4	3	2	1	
1071	568	2500	504	710	1450
951	990	1375	1125	313	488
951	990	1375	1125	313	488
913	504	710	1450	990	1375
845	600	600	1500	680	750
829	680	750	785	1100	856
829	680	750	785	1100	856
829	680	750	785	1100	856
659	1100	856	300	380	450
650	488	836	295	982	200
585	406	750	750	434	550
503	503	378	368	762	380
413	982	200	168	334	273
413	982	200	168	334	273
391	550	578	237	198	59
296	390	319	—	178	117
289	68	350	450	—	230
260	230	270	350	190	148
201	334	273	86	110	74
198	129	315	118	231	218
184	127	98	198	314	134
154	190	148	138	138	125
148	36	66	318	172	53
147	128	78	254	127	98
140	230	87	126	118	145
132	205	76	148	98	39
79	35	77	164	41	58
78	164	41	58	49	161
76	128	41	69	65	19
57	41	127	58	3	23
57	69	43	47	68	74
37	29	38	—	45	138
25	28	28	27	18	17
25	—	49	12	14	22
31	—	38	13	41	14
24	28	—	21	23	28
24	28	18	15	34	19
21	14	28	—	21	23
13	31	11	10	1	29
13	31	11	10	1	29
13	31	11	10	1	29
6	0	12	10	0	17
4	3	0	0	12	10

These dissection data are summarized in Table 2. Fifteen stations in 1945, and seven in 1946, yielded gland positive specimens.

It is noted that the earliest and the latest infective mosquitoes were found in May and November, which is comparable with observations reported by Mitzmain (1916 and 1919) for Louisiana and Alabama.

Average densities of *An. quadrimaculatus* obtained from station counts made weekly at all stations are shown for 1946 in Figure 1. These counts are somewhat lower than they were in 1945. Major peaks of abundance occurred in May and August of both years. Low points in April, May, June, and September are just over 11, 10, 12, and 15, respectively.

Station counts of *An. quadrimaculatus* from stations which yielded gland positive specimens are summarized in Table 3. The counts made during the weeks in which the positive specimens were collected are shown, along with the counts for each of the four weeks preceding that in which infective mosquitoes were collected. The average of the four weeks preceding the finding of infective specimens is also shown. Each gland positive specimen found is therefore represented by one horizontal line in Table 3, which is arranged from highest to lowest average of the station densities during the four weeks prior to the occurrence of the infective specimens. Station counts made during the weeks in which infective mosquitoes were collected, are seen to range from 10 to 1450. In consideration of the four weeks preceding the recognition of infective individuals, or the period during which the infections were probably acquired, station counts range from 0 to 2500. There are four instances in which the count was 0, and one in which it was 0 for 2 successive weeks. Average station counts during this period range from 4 to 1071.

DISCUSSION

The data presented show that 44 gland positive *An. quadrimaculatus* were collected in 22 mule stables during 1945 and 1946 in an area where malaria was moderately prevalent in 1943 and 1944 but in which a comparatively low incidence has existed since June, 1945 when mosquito dissections to find infected mosquitoes were begun. The average index station counts of *An. quadrimaculatus* for 4 weeks preceding the finding of infected specimens ranged from 4 to 1071, and the individual station counts in which the infected mosquitoes occurred ranged from 10 to 1450. Thus, the densities of *quadrimaculatus* for the 4 weeks preceding the finding of infective specimens and at the time the infected specimens were collected is extremely variable. The two lowest counts which included infective specimens were 10 and 17. The two lowest average records for the four weeks preceding the finding of infective specimens were 4 and 6. In one instance, even the complete absence of mosquitoes on two successive weekly observations was followed by the presence of an infective specimen 2 weeks later.

In considering the transmission of malaria, attention is given to period of time necessary from the contraction of infections by the mosquito to the maturation of sporozoites within the mosquito. It is therefore considered that the occurrence of gland positive specimens is influenced by the densities that existed during the preceding weeks. Four weeks are allowed in this paper to cover this period, and it is believed that mosquito densities during this period are indicative of conditions existing at the time of contraction of infections by the mosquitoes. Gland positive mosqui-

toes subsequently collected are a reflection of these earlier conditions, and cannot from the point of view of infectiveness be influenced by the densities encountered when the individuals have later matured sporozoites and become infective specimens. Considering that with the maturation of sporozoites, the mosquito had fulfilled its primary contribution to the act of malaria transmission, the feeding upon a susceptible host remains to be the only act necessary to complete transmission. No additional time element or other biological conditions necessary, it appears that the finding of sporozoite positive (gland positive) mosquitoes in moderate numbers in a malarious area is reasonable evidence that transmission is being effected, especially during the summer months.

A finding of particular significance in these studies is that infective mosquitoes may be present in considerable numbers throughout the season of malaria transmission, in stables in an area in which the houses had been sprayed with DDT. This may indicate that in the area under study, mosquitoes become infected outside of houses, a condition which was pointed out by Boyd (1930) who considered that the contraction of infection in situations outside of dwellings "is not an unlikely or even a rare occurrence during summer months." It is indicated, therefore, that in an area having a percentage of human carriers and mosquito vectors such as the one under study, if complete and immediate prevention of malaria transmission is to be obtained, resting places of anophelines outside of human dwellings as well as the dwellings themselves might require spraying with DDT.

SUMMARY AND CONCLUSIONS

1. Data are presented on the average densities of *An. quadrimaculatus* as measured by index station counts on premises which yielded 44 malaria infective specimens during 1945 and 1946. Infective specimens were found in one stable when average weekly counts for the 4 preceding weeks were only 4 on one occasion and 6 on another. The index counts at the time of these collections were 10 and 17, respectively. Complete absence of *An. quadrimaculatus* from a station for 2 weekly observations might be followed by the presence of infective mosquitoes 2 weeks later.

2. Thirty-three thousand five hundred and inety-three dissections of *An. quadrimaculatus* were made from June to November, 1945 and from May through September 10, 1946. With the exception of negative findings during June, 1945 and September, 1946, monthly infective rates ranged from 0.13 (July) to 4.21 (November) in 1945 and from 0.5 (July) to 0.11 (June and August) in 1946.

3. The earliest and latest infective *An. quadrimaculatus* respectively, were collected during the weeks ending May 18 and November 17.

4. It is concluded that in the presence of human malaria infection rates and mosquito vector densities such as those existing in the area under study, it is impossible from the data at hand to determine a minimum of *An. quadrimaculatus* density below which no hazard of malaria transmission would be expected to occur.

5. It is also concluded that transmission of malaria in this area is not restricted to the inside of houses and that residual DDT spraying of human habitations only is not alone adequate to eliminate completely the hazard of malaria transmission.

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MARK HOLLIS NOW ASST. SURGEON GENERAL

Mark Dexter Hollis, retiring President of the National Malaria Society, has been appointed Assistant Surgeon General and Chief of the Sanitary Engineering Division, of the U. S. Public Health Service, effective January 1, 1948.

During the war, Mark Hollis was a dominant figure in organizing and directing Malaria Control in War Areas, and in 1946 when the Communicable Disease Center was formed, he was named Officer in Charge. For the past year he has been in Washington as executive officer in the Office of the Surgeon General.

Mark Hollis was born September 24, 1908 in Buena Vista, Georgia. He graduated as a civil engineer from the University of Georgia and began his public health career in 1932. His career with the Public Health Service includes work on the Chesapeake Bay Pollution Survey, administrative duties in connection with typhus work, director of the division of engineering for the North Dakota Health Department, and an assignment with the Office of Stream Sanitation at Cincinnati, Ohio.

Harry Glenys Hanson, who was associated with Mark Hollis in malaria control and the Communicable Disease Center, succeeds him as Executive Officer in the Office of the Surgeon General.

PLASMODIUM MALARIAE IN SCHOOL SURVEYS IN SOUTH CAROLINA

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The South Carolina State Board of Health conducted county-wide thick film blood smear surveys from 1937 to 1943 among school children in 23 counties for the general purpose of locating malarious areas within this State. Findings of these studies for the positive smears of all species of plasmodia have been reported (McDaniel and Hemphill, in press). *Plasmodium malariae* was found on 295 of the smears. The present study gives the areas in which these 295 *P. malariae* smears were found, the distribution by race, sex and age of infected individuals and the month in which the positive smears were taken. The data are treated similarly to those of the 1937 and 1943 study using as a population basis the total smears of only the schools in which *P. malariae* was found.

Reports of prevalence of *Plasmodium malariae* in this country are meager and infrequent. Andrews reported 2.0 per cent and 0.5 per cent of positive malaria survey smears in Georgia in 1938 and 1939 respectively to be *P. malariae* (Andrews, 1940, 1941). Faust reported on deaths from malaria that were confirmed by laboratory examination in 1936 from Mississippi and Florida (Faust, 1937). Four per cent of the white deaths and two per cent of the colored deaths in Mississippi and 2.5 per cent of the deaths in Florida were due to *P. malariae*. Barber and Komp reported one per cent of 1517 cases of malaria in seven Southern States to be quartan (Barber and Komp, 1929). The U. S. Public Health Service made surveys from 1913 to 1914 of cases of malaria by circularizing physicians in some Southern states (Von Ezdorf et al., 1917 a, b, c, 1914). Two to sixty cases were reported diagnosed microscopically as quartan malaria from North Carolina, Louisiana, Kentucky, Tennessee, and Alabama.

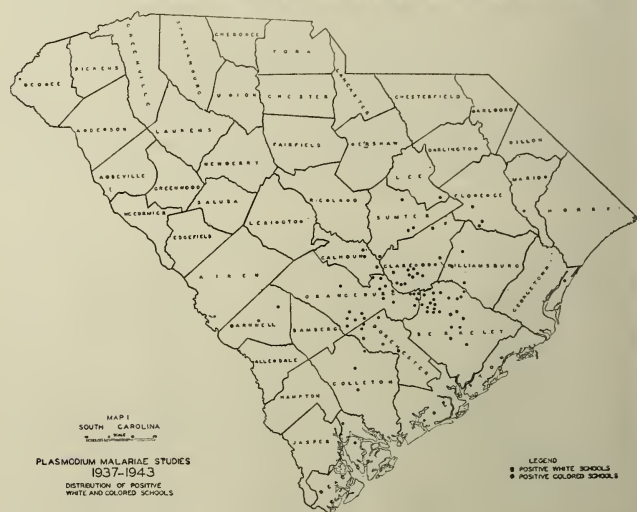
Positive *P. malariae* infections were found in school children of fifteen of the twenty-three Coastal Plains counties surveyed (Table 1). All schools for white and colored children were surveyed in groups of four to five counties each year. The schools in the counties in the Santee River area were resurveyed in 1940 and 1943 because of the development of a large hydro-electric and navigation impoundment. No schools surveyed in 1937 showed *P. malariae* present and only one in 1938. Schools in which *P. malariae* infections were found are concentrated in an area along the Santee River in Berkeley, Clarendon, and Orangeburg Counties. Schools having rarer positives tend to radiate from this area of greatest concentration (Map 1). Location of schools with positive *P. malariae* smears tends to follow the same general pattern of concentration as that of all schools having positives of all species of malaria during the 1937 to 1943 surveys (Map 2).

A total of 106,559, smears was collected in the surveys of 1937 to 1943 from 560 schools for white children and from 916 schools for colored children. Of this total,

TABLE 1

Plasmodium malariae *in Thick Film Blood Smear Surveys in Schools in Fifteen Counties in South Carolina, 1938–1943*

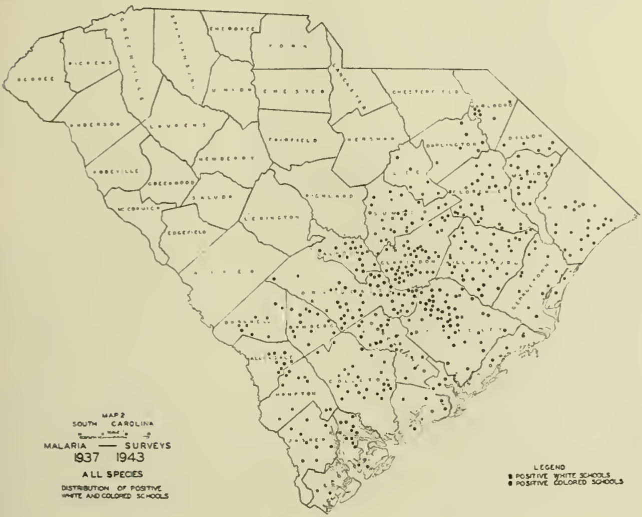
COUNTY	1938		1939		1940		1941		1942		1943		TOTAL POSITIVE
	W	C	W	C	W	C	W	C	W	C	W	C	
Barnwell		1				1							2
Beaufort					1	2							3
Berkeley			1	64	3	61						10	139
Calhoun				4								3	7
Charleston						1							1
Clarendon			1	22							1		24
Colleton				3									3
Dorchester				1	1	6							8
Florence							2	1					3
Georgetown						2							2
Lee										1			1
Marion								1					1
Orangeburg			2	54		23						10	89
Sumter			1	8									9
Williamsburg								1	1	1			3
Total		1	5	156	5	96	2	3	1	2	1	23	295



MAP 1

10,902 were from the thirteen schools for white children and the seventy-two schools for colored children in which the 295 positive *P. malariae* smears were found.

Smears numbering 2,204 or 20.2 per cent were from the thirteen schools for white children and 8,698 smears or 79.8 per cent were from the 72 schools for colored chil-



MAP 2

TABLE 2

Plasmodium malariae *and All Species in White and Colored School Children in South Carolina, 1937–1943*

RACE	NUMBER EXAMINED	NUMBER NEGATIVE	NUMBER POSITIVE		PER CENT POSITIVE	
			P. mal.	All spec.	*P. mal.*	All spec.
White........	2204	2155	14	49	0.64	2.22
Colored.....	8698	7603	281	1095	3.23	12.59
Total.....	10902	9758	295	1144	2.71	10.49

dren. These 2,204 smears from white children contributed 14 or 0.64 per cent *P. malariae* smears and the 8,698 smears from colored children contributed 281 or 3.23 per cent *P. malariae* smears (Table 2).

One or more schools in fifteen counties showed positive *P. malariae* smears. Schools

for white children in only eight of the fifteen counties showed positive *P. malariae* smears (Table 3). Schools in Berkeley and Orangeburg Counties were surveyed in each of three years and in Barnwell, Calhoun, Clarendon, Dorchester, and Williamsburg Counties in each of two years.

TABLE 3 *Plasmodium malariae and Total All Species in School Surveys in South Carolina by County and Race, 1937–1943*

COUNTY	WHITE AND COLORED							WHITE							COLORED						
	No. schls.	Pop. exam.	No. neg.	No. pos. *P. mal.*	No. pos. All Spec.	% Pos. *P. mal.*	% Pos. *all spec.*	No. schls.	Pop. exam.	No. neg.	No. pos. *P. mal.*	No. pos. All Spec.	% Pos. *P. mal.*	% Pos. all spec.	No. schls.	Pop. exam.	No. neg.	*No. pos. P. mal.*	No. pos. All Spec.	% Pos. *P. mal.*	% Pos. all spec.
Barnwell...	2	316	313	2	3	0.63	0.95	0	—	—	—	—	—	—	2	316	313	2	3	0.63	0.95
Beaufort...	2	449	434	3	15	0.67	3.34	1	368	367	1	1	0.27	0.27	1	81	67	2	14	2.47	17.28
Berkeley...	23	3495	2911	139	584	3.98	16.71	3	765	737	4	28	0.52	3.66	20	2730	2174	135	556	4.95	20.45
Calhoun....	3	156	136	7	20	4.49	12.50	0	—	—	—	—	—	—	3	156	136	7	20	4.49	12.82
Charleston	1	52	50	1	2	1.92	3.85	0	—	—	—	—	—	—	1	52	50	1	2	1.92	3.85
Clarendon..	13	1108	1003	24	105	2.17	9.48	2	294	287	2	7	0.68	2.38	11	814	716	22	98	2.70	12.04
Colleton....	3	235	228	3	7	1.28	2.98	0	—	—	—	—	—	—	3	235	228	3	7	1.28	2.98
Dorchester	6	229	121	8	8	3.49	3.49	1	16	15	1	1	6.25	6.25	5	213	206	7	7	3.29	3.29
Florence...	3	737	730	3	7	0.41	0.95	2	437	432	2	5	0.46	1.14	1	300	298	1	2	0.33	0.66
George-town.....	1	70	68	2	2	2.86	2.86	0	—	—	—	—	—	—	1	70	68	2	2	2.86	2.86
Lee........	1	104	99	1	5	0.96	4.81	0	—	—	—	—	—	—	1	104	97	1	5	0.96	4.81
Marion.....	1	75	72	1	3	1.33	4.00	0	—	—	—	—	—	—	1	75	72	1	3	1.33	4.00
Orangeburg	19	2878	2535	89	343	3.09	11.92	2	146	142	2	4	1.37	2.74	17	2732	2393	87	339	3.18	12.41
Sumter.....	4	294	268	9	26	3.06	8.84	1	55	54	1	1	1.82	1.82	3	239	214	8	25	3.35	10.46
Williams-burg.....	3	704	690	3	14	0.43	1.98	1	123	121	1	2	0.81	1.63	2	581	569	2	12	0.34	2.07
Total....	85	10902	9758	295	1144	2.71	10.49	13	2204	2155	14	49	0.64	2.22	72	8698	7603	281	1095	3.23	12.59

TABLE 4

Plasmodium malariae *in Schools in South Carolina by Race and Sex, 1937–1943*

	WHITE			COLORED			WHITE AND COLORED		
	Male	Female	Not stated	Male	Female	Not stated	Male	Female	Not stated
No. exam................	1152	1038	14	3870	4753	75	5022	5791	89
No. neg..................	1121	1020	14	3370	4160	73	4491	5180	87
No. pos. *P. mal*...........	10	4	0	141	139	1	151	143	1
No. pos. all spec..........	31	18	0	500	593	2	531	611	2
% Pos. *P. Mal*............	0.87	0.38	0.00	3.64	2.92	1.33	3.01	2.48	1.13
% Pos. all spec..........	2.77	1.74	0.00	12.92	12.48	2.66	10.60	10.58	2.27

Sex distribution differed considerably between the races (Table 4). Of the 2,204 smears from whites, 1,152 or 52.27 per cent were from males and 1,038 or 47.10 per cent from females and 14 or 0.64 per cent had no sex recorded. Of the 8,698 smears from colored persons, 3,870 or 44.49 per cent were males; 4,753 or 54.64 per cent were

females and 75 or 0.85 per cent had no sex recorded. These differences in sex distribution by race are statistically significant; there being significantly more white males than white females; more colored females than colored males; more white males in comparison with white total than colored males in comparison with colored total; and more colored females in comparison with colored total than white females in comparison with white total.

TABLE 5 *Plasmodium malariae in Schools in South Carolina by Age, 1937–1943*

AGE	WHITE AND COLORED						WHITE						COLORED					
	No. exam.	No. neg.	No. pos. *P. mal*	No. Pos. all spec.	% Pos. *P. mal.*	% Pos. all spec.	No. exam.	No. neg.	No. pos. *P. mal.*	No. pos. all spec.	% Pos. *P. mal.*	% Pos. all spec.	No. exam.	No. neg.	No. Pos. *P. mal.*	No. pos. all spec.	% Pos. *P. mal.*	% Pos. all spec.
yrs.																		
5	80	64	5	16	6.25	20.00	21	21	0	0	0.00	0.00	59	43	5	16	8.47	29.12
6	987	904	14	83	1.42	8.41	320	312	1	8	0.31	2.50	667	592	13	75	1.95	11.24
7	1118	984	35	134	3.14	12.04	225	220	1	5	0.44	2.22	893	764	34	129	3.81	14.45
8	1124	1017	24	107	2.14	9.52	288	285	1	3	0.44	1.32	836	732	23	104	2.75	12.44
9	1042	931	28	111	2.69	10.65	253	249	2	4	0.79	1.58	789	682	26	107	3.30	13.56
5–9	4351	3900	106	451	2.44	10.39	1107	1086	5	20	0.45	1.81	3244	2813	101	431	3.12	13.32
10	1165	1050	35	115	3.02	9.87	296	285	4	10	1.49	3.38	869	764	31	105	3.57	12.08
11	960	863	27	97	2.81	10.10	234	231	2	3	0.85	1.28	726	632	25	94	3.44	12.95
12	986	862	30	124	3.04	12.58	188	181	0	7	0.00	3.72	798	681	30	117	3.76	14.66
13	807	723	26	84	3.22	10.41	138	134	2	4	1.45	2.90	669	589	24	80	3.59	11.96
14	661	574	25	87	3.78	13.16	77	75	1	2	1.30	2.60	584	499	24	85	4.11	14.55
10–14	4579	4072	143	507	3.13	11.12	933	906	9	26	0.97	2.79	3646	3165	134	481	3.69	13.25
15–19	927	798	32	129	3.45	13.92	101	98	0	3	0.00	2.97	826	700	32	126	3.87	15.25
20 & over	49	47	0	2	0.00	4.08	8	8	0	0	0.00	0.00	41	39	0	2	0.00	4.89
Age not given	996	941	14	55	1.41	5.52	55	55	0	0	0.00	0.00	941	886	14	55	1.49	5.84
Total	10902	9758	295	1144	2.71	10.52	2204	2155	14	49	0.64	2.22	8698	7603	281	1095	3.24	12.63

These surveys were largely of school children in the elementary grades. Hence the majority of the smears were from children 6 to 14 years of age (Table 5). Essentially all those 20 years of age and over were teachers and in many instances not residents of the particular school community. Some high school students were examined on request. *Plasmodium malariae* in white children was distributed through the ages 6 to 14 years with ages 10, 13 and 14 years showing 1.49 per cent, 1.45 per cent, and 1.30 per cent respectively. All other ages among white children showed less than one per cent positive for *P. malariae*. *P. malariae* in colored children was distributed through ages 5 to 19 years. Age 5 years showed the highest per cent positive, 8.47. All other ages showed 2 to 4 per cent positive.

For a total of 996 or 9.14 per cent of the 10,902 smears, age of donor was not recorded. After examination of the original records, it was assumed that the age distribution of these 996 did not differ materially from the age distribution of the

remainder of the group since failure to record the ages was noted to be in almost all instances either by entire schools or by class rooms within the schools. Fourteen smears were positive for *P. malariae* among these 996 or 1.41 per cent while the average per cent *P. malariae* positive for the group was 2.71. The percentage of

TABLE 6

Plasmodium malariae *Contrasts, South Carolina, 1937–1943*

CONTRAST FACTORS	CRITICAL RATIO	SIGNIFICANT	FACTOR HAVING HIGHEST PERCENTAGE
Race:			
W:C	10.16	Yes	C
Sex:			
WC-M:WC-F	1.68	No	M
C-M:C -F	1.86	No	M
C-M:W -M	6.81	Yes	C
C-F :W -F	8.19	Yes	C
W-M:W -F	1.47	No	M
Age:			
WC 5–9 M:F	0.09	No	M
WC 10–14 M:F	1.97	Yes	M
WC 15+ M:F	0.03	No	F
WC 10+ M:F	1.75	No	M
W 5–9 M:F	1.30	No	M
W 10–14 M:F	0.70	No	M
W 15+ M:F	No positive *P. malariae*		
W 10+ M:F	0.71	No	M
C 5–9 M:F	0.02	No	F
C 10–14 M:F	2.17	Yes	M
C 15+ M:F	0.17	No	M
C 10+ M:F	2.02	Yes	M
5–9 W:C	7.28	Yes	C
10–14 W:C	6.14	Yes	C
15+ W:C	No white *P. malariae* positives		
10+ W:C	7.04	Yes	C
WC 5–9 :10–14	1.96	Yes	10–14
WC 10–14 :15+	0.03	No	15+
WC 5–9 :10+	2.14	Yes	10+
W 5–9 :10–14	1.35	No	10–14
W 10–14 :15+	No *P. malariae* for the 15+		
W 5–9 :10+	1.17	No	10+
C 5–9 :10–14	1.31	No	10–14
C 10–14 :15+	0.01	No	15+
C 5–9 :10+	1.38	No	10+

P. malariae among the 996 age-not-given group is significantly less than the percentage of *P. malariae* for the entire group. Contrasts between the age groups did not include the 996 for which age was not given. A study of contrasts of *P. malariae* infections by age groups, sex and race is given in Table 6.

These surveys were made usually during September–December though a few smears were collected during the other months of the year except June. All positive *P. malariae* smears were collected during October, November, and December (Table 7). All smears from schools for white children showing *P. malariae* were collected in October and November; 8, 361 smears or 96.12 per cent of the smears from schools for colored children were collected during October and November. The highest per cent of positive smears for *P. malariae* were collected in December. These findings are in conformity with Boyd's statement that "*P. malariae* of quartan is reported to be more commonly noted in the late fall or winter months . . . " (Boyd, 1930).

TABLE 7

Smears by Months for Schools in which P. malariae *was Found, 1938–1943*

MONTH	MALE & FEMALE	POS. P. MAL.	% POS P. MAL.	CUMULATIVE MALE & FEMALE	CUMULATIVE POS. P. MAL.	CUMULATIVE % POS. P. MAL.	CONTRAST WITH TOTAL OF OTHER MONTHS OF LESS PERCENTAGE	
							Critical ratio	Significant
White and Colored:								
December	337	23	6.82	10902	295	2.71	3.08	Yes
November	5692	155	2.72	10565	272	2.57	1.04	No
October	4873	117	2.40	4873	117	2.40		
Total	10902	295	2.71					
Colored:								
December	337	23	6.82	8698	281	3.23	2.69	Yes
November	4497	147	3.27	8361	258	3.09	1.06	No
October	3864	111	2.87	3864	111	2.87		
Total	8698	281	3.23					
White:								
November	1195	8	0.67	2204	14	0.64	0.24	No
October	1009	6	0.59	1009	6	0.59		
Total	2204	14	0.64					

Statistical studies of significance of difference of percentage of *P. malariae* smears found by race, sex, and age of individuals, and area and month in which the smears were taken were made using the "standard error" statistical technique for determination of significance of differences (uncorrelated data formulae—Hall). The criterion of significance used in this paper was a critical ratio of 1.96 or greater. Through the remainder of this paper, critical ratios of less than 1.96 are referred to as "not significant," those of 1.96 to 3.00 as "significant," those of 3.00 and greater as "highly significant."

Table 6 shows the contrasts studied, the resultant critical ratios, whether the contrast is significant and which of the contrasting factors presented the higher percentage.

P. malariae was found among colored persons more often than among white persons with a percentage that is highly significant.

Highly significant differences result when percentages of *P. malariae* among colored males are contrasted with those for white males and when colored females are contrasted with white females. Colored persons had the preponderance of *P. malariae* infections among each sex. No significant difference was found between males and females when the total white and total colored were considered together or when the races were considered separately.

No significant differences were found between the sexes for the 5–9 year group, for the total white and colored, or for the colored, or for the white. When the white and colored 10–14 year group was contrasted by sex, a resultant critical ratio of 1.97 barely passed the accepted criterion of significance; sex contrast of the white group 10–14 years was not significant but the colored group 10–14 years by sex showed a significant difference in which the males presented the preponderance. This indicates that the weight of male preponderance of *P. malariae* infections was in the colored group. No significant difference was shown between the males and females of the 15 years and over group for either white and colored or the races considered separately. When the 10–14 year and 15 year and over groups were combined no significant difference appeared by sex for the white and colored total nor for the white, but a significant difference for the colored was shown, males presenting the preponderance. When the age groups were contrasted by race, highly significant differences appeared with the colored presenting the preponderance for each age group. Contrasts of the age group 5–9 years against the group 10–14 years showed no significant difference for the white and colored total, nor for the whites, nor for the colored. No significant difference appeared between the 10–14 year and the 15 year and over groups. A significant difference appeared for the white and colored total 5–9 year group against the 10 year and over group, the preponderance favoring the 10 year and over group but neither race alone for these age groups showed significant differences. The tendency for difference of significance with a preponderance favoring the 10 year and over age group for *P. malariae* positives was similar to that reported for the contrasts of age groups in the study of total positives of the 1937–1943 surveys.

Smears by counties, *P. malariae* and percentage of *P. malariae* and cumulative arrangements of these together with contrasts of each county area against the sum of the other counties having less percentage of *P. malariae* and degree of significance of difference is shown in Table 8 for the white and colored combined, in Table 9 for whites and Table 10 for colored.

Study of significance between the percentage of *P. malariae* infections found in the schools, white and colored total (Table 8), showed that the areas indicated by the schools of Calhoun, Berkeley, Dorchester, Orangeburg, Sumter, Georgetown, and Clarendon counties are statistically more significant than those of Charleston, Marion, Colleton, Lee, Beaufort, Barnwell, Williamsburg and Florence counties. No significant difference appeared between the areas for the whites.

Percentage of *P. malariae* infections among the colored persons by area indicated that the areas of Berkeley, Calhoun, Sumter, Dorchester, Orangeburg, Georgetown

TABLE 8

Plasmodium malariae *Positives and Percentages, White and Colored Persons in South Carolina, 1937–1943*

COUNTY	MALE AND FEMALE	P. MAL. POS.	% P. MAL. POS.	CUMULATIVE MALE & FEMALE	CUMULATIVE P. MAL. POS.	CUMULATIVE % P. MAL. POS.	CONTRAST WITH TOTAL OF OTHER COUNTIES OF LESS PERCENTAGE	
							Critical ratio	Significant
Calhoun	156	7	4.49	10902	295	2.71	1.09	No
Berkeley	3495	139	3.98	10746	288	2.68	5.22	Yes
Dorchester	229	8	3.49	7251	149	2.05	1.21	No
Orangeburg	2878	89	3.09	7022	141	2.01	5.03	Yes
Sumter	294	9	3.06	4144	52	1.25	1.90	No
Georgetown	70	2	2.86	3850	43	1.12	0.89	No
Clarendon	1108	24	2.17	3780	41	1.08	3.30	Yes
Charleston	52	1	1.92	2672	17	0.64	0.69	No
Marion	75	1	1.33	2620	16	0.61	0.56	No
Colleton	235	3	1.28	2545	15	0.59	1.03	No
Lee	104	1	0.96	2310	12	0.52	0.48	No
Beaufort	449	3	0.67	2206	11	0.50	0.50	No
Barnwell	316	2	0.63	1757	8	0.46	0.44	No
Williamsburg	704	3	0.43	1441	6	0.42	0.06	No
Florence	737	3	0.41	737	3	0.41		
Total	10902	295	2.71					

TABLE 9

Plasmodium malariae *Positives and Percentages, White Persons in South Carolina, 1937–1943*

COUNTY	MALE AND FEMALE	P. MAL. POS.	% P. MAL POS.	CUMULATIVE MALE & FEMALE	CUMULATIVE P. MAL. POS.	CUMULATIVE % P. MAL. POS.	CONTRAST WITH TOTAL OF OTHER COUNTIES OF LESS PERCENTAGE	
							Critical ratio	Significant
Dorchester	16	1	6.25	2204	14	0.64	0.93	No
Sumter	55	1	1.82	2188	13	0.59	0.70	No
Orangeburg	146	2	1.37	2133	12	0.56	0.89	No
Williamsburg	123	1	0.81	1987	10	0.50	0.40	No
Clarendon	294	2	0.68	1864	9	0.48	0.45	No
Berkeley	765	4	0.52	1570	7	0.45	0.45	No
Florence	437	2	0.46	805	3	0.37	0.45	No
Beaufort	368	1	0.27	368	1	0.27		
(No whites in other seven counties.)								
Total	2204	14	0.64					

and Clarendon Counties have statistically significant higher percentages of *P. malariae* than the areas of Beaufort, Charleston, Marion, Colleton, Lee, Barnwell, Williamsburg and Florence Counties (Table 10).

These statistical indications become more meaningful when they are studied in connection with Map 1, showing the location of schools in which *P. malariae* was found.

Smears collected in December from colored persons showed a significant difference over these collected during November and October (Table 7). No significant difference appeared for the white persons between November and October. No smears were taken in December for the white persons in schools in which *P. malariae* was found.

TABLE 10

Plasmodium malariae *Positives and Percentages, Colored Persons in South Carolina 1937–1943*

COUNTY	MALE AND FEMALE	P. MAL. POS.	% P.MAL. POS.	CUMULATIVE MALE & FEMALE	CUMULATIVE P. MAL. POS.	CUMULATIVE % P. MAL. POS.	CONTRAST WITH TOTAL OF OTHER COUNTIES OF LESS PERCENTAGE	
							Critical ratio	Significant
Berkeley	2730	135	4.95	8698	281	3.23	5.43	Yes
Calhoun	156	7	4.49	5968	146	2.45	1.26	No
Sumter	239	8	3.35	5812	139	2.39	0.85	No
Dorchester	213	7	3.29	5573	131	2.35	0.79	No
Orangeburg	2732	87	3.18	5360	124	2.31	4.35	Yes
Georgetown	70	2	2.86	2628	37	1.41	0.74	No
Clarendon	814	22	2.70	2558	35	1.37	3.22	Yes
Beaufort	81	2	2.47	1744	13	0.75	1.04	No
Charleston	52	1	1.92	1663	11	0.66	0.68	No
Marion	75	1	1.33	1611	10	0.62	0.55	No
Colleton	235	3	1.28	1536	9	0.59	1.08	No
Lee	104	1	0.96	1301	6	0.46	0.55	No
Barnwell	316	2	0.63	1197	5	0.42	0.60	No
Williamsburg	581	2	0.34	881	3	0.34	0.02	No
Florence	300	1	0.33	300	1	0.33		
Total	8698	281	3.23					

SUMMARY AND CONCLUSIONS

A total of 10,902 blood smears was taken among 85 schools in South Carolina in which 295 *Plasmodium malariae* positives were found. Smears from colored persons were found to have *P. malariae* more often and with a preponderance that was highly significant. It appears that *P. malariae* infection is primarily one of the colored race in this State.

No significant sex difference appeared for either white or colored or for both races combined. There was a tendency for the males 10 years of age and over to show a higher percentage of *P. malariae* than the females of the same age group.

The ten year and older age group showed higher percentages of *P. malariae* infections than the 5 to 9 year age group with a preponderance that is statistically significant for both races combined. No significant difference appeared for either race

considered separately for these age groups but the weight of either favored the ten year and older age group.

Plasmodium malariae was a greater problem in areas of the counties of Calhoun, Berkeley, Dorchester, Orangeburg, Sumter, Georgetown and Clarendon than in areas of the other counties of Charleston, Marion, Colleton, Lee, Beaufort, Barnwell, Williamsburg, and Florence. The concentration of the problem was along the upper Santee River. Apparently the greatest problem of *P. malariae* parallelled closely the greatest problem of all species of malaria in South Carolina reported in malaria surveys of 1937–1943.

Percentage of *P. malariae* found among smears taken in December was significantly greater than those taken in November or October. No significant difference appeared between the percentage of *P. malariae* among smears collected in November and in October.

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NATIONAL MALARIA SOCIETY

Meeting Conjointly With The American Society of Tropical Medicine and the American Academy of Tropical Medicine

MINUTES, 1947

OFFICERS

President—Mr. Mark D. Hollis, Washington, D. C.
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Mr. L. M. Clarkson, Atlanta, Georgia
Dr. Justin M. Andrews, Atlanta, Georgia
Dr. Mark F. Boyd, Tallahassee, Florida

Tuesday, December 2, 1947

The National Malaria Society convened for its 30th annual session in the Hotel Atlanta-Biltmore, Atlanta, Georgia, at 9:00 a.m. with Mr. Mark D. Hollis presiding. The President appointed temporary auditing and resolution committees. Twelve papers were read and one presented by title. The session adjourned at 12:00 noon.

Wednesday, December 3, 1947

The Society reconvened in the Hotel Atlanta-Biltmore at 9:00 a.m. During this scientific session twelve papers were read and two presented by title. Adjournment was at 12:10 p.m.

Thursday, December 4, 1947

The business meeting of the National Malaria Society was held at 1:30 p.m. At 2:15 p.m. the National Malaria Society met conjointly with the American Society of Tropical Medicine; Dr. E. I. Salisbury, President of the latter society, presided. A program of ten papers was presented. The meeting adjourned *sine die* at 4:55 p.m.

During the business session of the Society, President Mark D. Hollis presided. The minutes of the 1946 annual meeting held in Miami, Florida, were approved as published in the March, 1947, issue of the Journal of the National Malaria Society.

The reports of the meetings of the Board of Directors during 1947 were read.

The Secretary-Treasurer reported, as follows:

From the 1946 roster of 504 active members, two (Dr. Robert Wilson and Mr. T. H. Milford) have been lost by death, six by resignation, and twenty-six have been dropped because of delinquency in dues. A total of 83 new members has been

elected and one reinstated, making an active membership list of 554 and representing a gain of 50 members; of these, 458 are in good standing as of November 29, 1947.

The status of the treasury, as of the close of business November 29th, was:

Balance of October 31, 1946	$5,026.70
Receipts from delinquent, current, and advance dues, subscriptions, advertising, sale of back issues, etc.	3,391.96
	$8,418.66
Expenditures before paying for 3rd and 4th issues of the 1947 Journal but including the cost of 2nd, 3rd, and 4th issues of the 1946 Journal	3,934.33
Balance	$4,484.33

Of the balance on hand November 29, 1947, $4,255.54 is in the publication fund. Assets estimated for 1947, including the above cash balance, total $4,988.86; estimated liabilities are $1,356.25, which leaves the estimated net resources available at the end of the year to be $3,632.61.

This report was accepted by the Society.

Mr. J. L. Porter, Chairman of the Committee on Auditing, stated that the books and accounts of the Secretary-Treasurer had been found to be correct and recommended that honoraria be granted in the amount of $100.00 to the Secretary's stenographer and $25.00 to the Editor's stenographer. The National Malaria Society adopted the report of the auditing committee.

Dr. V. H. Haas reported for the Committee on Medical Research; copies of this report had been distributed. Dr. Haas moved that the work of the Committee be continued. This motion was adopted.

Mr. J. L. Henderson presented the report which had been previously distributed by the Committee on Sanitary Engineering and recommended its adoption. It was moved by Mr. Stevens that the report with its attachment be adopted as the official code of the Society in the engineering field of malaria control. This motion was amended by changing the word "code" to "guide" and was carried.

A short report was presented by Dr. E. C. Faust, Representative to the Council of the American Association for the Advancement of Science.

Dr. E. H. Hinman, of the Committee on Resolutions, introduced resolutions on the Society's regret upon the death of Dr. Robert Wilson and Mr. T. H. Milford instructing the Secretary to transmit an expression of sympathy to their families. Other resolutions expressed the appreciation of the Society to the Medical Officer in Charge, Communicable Disease Center of the U. S. Public Health Service, and to the Committee on Local Arrangements, of which Dr. Vernon Link was Chairman, for their generous efforts in making the meetings a success; thanked the Manager of the Hotel Atlanta-Biltmore for the splendid facilities provided for the sessions; and expressed appreciation to the Editor, Mr. Fred L. Knowles, and the Secretary-Treasurer, Dr. M. D. Young, for the progress made during the year in improving and expanding the Journal and the growth of the membership. These resolutions were adopted on motion by the Society.

Dr. E. H. Hinman moved that a committee be appointed to study broadening the

scope of the activity of the Society to include insect-borne diseases and that a report be presented at the next meeting. Dr. Faust recommended that Dr. Strode's suggestion for coordinating the aims and purposes of the American Society of Tropical Medicine, the American Academy of Tropical Medicine, and the National Malaria Society be considered by this committee. The motion with this amendment was passed.

Under new business, it was moved and adopted that the annual dues be increased to $4.00 and that By-Laws 4c and 6 be revised.

Dr. L. L. Williams, Jr. suggested that in arranging the future programs the Program Committee request the speakers to present only important results of the work reported and that time for discussion of each paper be arranged. This motion was carried.

The following officers for 1948 were elected by a ballot sent to the membership in advance of the meeting and announced at the annual meeting:

President-Elect—Dr. Wendell Gingrich

Vice President—Mr. Nelson H. Rector

Director (for 3-year term)—Dr. E. L. Bishop

The business meeting adjourned at 2:10 p.m.

LIST OF NEW MEMBERS OF THE NATIONAL MALARIA SOCIETY 1946–47

(Additions to the list published in the Journal, 4(4): 351–64, December, 1945)

**Membership effective with the year 1948*

AITKEN, Dr. Thomas H. G., Rockefeller Foundation, %ERLAAS, Piazza Garibaldi, Cagliari' Sardinia, Italy
*AKINS, Harvey, Malaria Investigations, USPHS, 847 Union Avenue, Memphis 3, Tenn.
ALVARADO, Dr. Carlos Alberto, Direccion Nacional de Salud Publica, Avenida Mitre 956, Tucuman (FCCA), Argentina
ALVING, Dr. Alf S., Department of Medicine, University of Chicago, Chicago, Ill.
ANTHONY, Dr. Sarkis J., 17 Cedar Street, Buffalo 4, N. Y.
ANTUNES, Dr. Paulo C. Azevedo, Faculdade de Higiene, Caixa Postal 99-B, Sao Paulo, Brazil
ARNOLD, Dr. David, 505 Buell Ave., Joliet, Illinois
ARNOLD, Frank T., Jr., State Board of Health, Columbia, S. C.
ARQUIE, Dr. Emile, Ecole L'Application du Service de Sante Colonial, Le Pharo, Marseille, France
ATCHLEY, Dr. John A., 1513 Marquette Rd., Joliet, Ill.
ATCHLEY, Dr. Floyd O., Defiance College, Defiance, Ohio
BALFOUR, Dr. Marshall C., 1320 Peking Rd., West, Shanghai, China
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DR. LEONARD A. SCHEELE NAMED NEW SURGEON GENERAL USPHS

Doctor Leonard A. Scheele, who will become Surgeon General of the United States Public Health Service on April 6

To succeed Dr. Thomas Parran, Surgeon General of the U. S. Public Health Service for the past 12 years whose term expires April 6, the U. S. Senate on February 25, 1948 confirmed the appointment of Dr. Leonard A. Scheele.

A graduate of the University of Michigan and the medical school of Wayne University, Detroit, Dr. Scheele has devoted his entire professional life to public health work. He has been director of the National Cancer Institute, National Institute of Health, since July, 1947.

Entering the Public Health Service as an Assistant Quarantine Officer for the port of San Francisco in 1934, Dr. Scheele began to specialize in cancer in 1937. He was appointed a Special Fellow at Memorial Hospital, New York City, that year and, upon completion of his fellowship in 1939, he was assigned to the National Cancer Institute.

During the war, Dr. Scheele was detailed to the War Department where his distinguished service both in the United States and Europe won him three military decorations: the Legion of Merit, the Typhus Medal and the French Order of Public Health. He returned to the National Cancer Institute in 1946.

Dr. Scheele is a member of the American Medical Association, the American Public Health Association, the American Association for the Advancement of Science, the American Association for Cancer Research, and the American Public Health Cancer Association.

Commenting on the appointment, Dr. Parran said: "The President is to be congratulated upon his appointment of Dr. Scheele as Surgeon General of the U. S. Public Health Service. Dr. Scheele is one of the outstanding figures in public health in this country. He possesses both the professional and personal qualifications to be a great Surgeon General. I wish for him long years of useful public service in this responsible position."